Vol. XXII No. 2 Whole No. 184

FEBRUARY, 1922

SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois under the Act of March 3, 1879

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WHAT SHALL BE THE PROGRAM IN EDUCATION FOR CITY SCHOOL SYSTEMS?

BY PETER A. MORTENSON,

Superintendent of Schools, Chicago, Ill

God made the country; man made the town. God wrought with consummate skill and infinite patience through the ages. Man has created cities, almost over night, with no comprehensive plan, no unity, no coherence. He has permitted peasants from distant shores to huddle in tenements under conditions unspeakable; he has encouraged the massing of groups of foreigners, each colony fostering an alien language, having old world traditions and little knowledge of community life. Even the well-to-do have accepted the apartment as a substitute for a separate home, until normal family life has become scarcely more than a memory. In the great urban centers, community sense tends to disappear. Each area is but an extension of the adjoining one. Neighborhood consciousness scarcely exists when neighbors are not even recognized. The educational objectives sought in such centers are fixed; the programs for their attainment may vary. The foremost objective in all public education is training for citizenship in its broadest sense.

The experiences of the past few years have brought to light certain fundamental national weaknesses. For sixty years, America has been the land of opportunity, not only for the oppressed, politically, but also for those to whom economic opportunity has been denied. Immigrants by thousands have hastened to our shores. Of this migration, the peoples of eastern and southern Europe have recently formed a large part. Having suffered constant repression, their notion of liberty is too often license. Lacking education and the culture, which comes through generations of the cultivation of spiritual ideals, their reaction to prosperity is often merely the gratification of the senses. Their experience leads them to value highly the

benefits which are conferred on them by this country, but too often they are not equally sensitive to the duties and obligations which accompany citizenship. Having welcomed them here, it is now our duty to see that they, and more especially their children, receive such training as will enable them to acquire speedily the ideas and ideals for which this country stands: Equality before the law, the duty of the minority to acquiesce in the decisions of the majority, the idea of mutual concession to promote the general good, and the principles of fair play must be made a part of the working philosophy of our adopted citizens. In certain large cities, associations of commerce are helping in this work by interesting their own members in opening classes in citizenship for employees on company time. The value of such lessons is not only in preparation for citizenship, but in acquiring the ability to understand our common language, to follow directions intelligently, and in gaining a growing sympathy with community ideals. But, helpful as this work for adults is, it is the children who must be given a real vision of America, if our nation is to stand secure.

The need of more training for those who do not enter the professions has brought about a raising of the compulsory school age. In a number of states, the period of training has been extended by the establishment of part-time or continuation schools. As a result, many pupils are staying in the elementary school, who formerly left as soon as they had completed the minimum requirements demanded by the state. The percentage of pupils entering high school from the elementary school is much greater than was formerly the case. These two facts have given rise to a number of problems. The question of housing, especially in the secondary schools, is an acute one. Not only must space be provided to care for new pupils but since the cost of a modern, cosmopolitan high school runs into the millions, some means must be found to care for a greater number of pupils in schools already established, through more extended use of buildings. In the past, the high-school pupil was recruited from a somewhat selected group. In the days to come, this group is to be greatly enlarged, probably with some lowering of its average ability. This necessitates, not only a restudy of the content of education, but also of the form of organization in order that there may be better articulation between the several groups through which the school system is now functioning.

This increase in numbers also raises another problem. In recent years, the demands made upon the public school by the community have steadily grown. The course of study has been constantly enriched by the inclusion of many subjects which were formerly not considered a part of public-school education. Many so-called fads of a few years ago are now regarded as integral parts of the school course; but more than that, the public demands that special provision be made for exceptional children, such as the blind, the deaf, and the subnormal; that the physical needs of those who are normal be cared for through doctor, nurse and dentist; that the child who is undernourished or whose parents are prevented by economic necessity from properly providing for him be cared for at the expense of the state. These things are right and should be done, but they add financial burdens. As a result, educational expenditures have increased during the last few years with tremendous rapidity. The amount of support which the community can afford the schools is limited by economic law, and there are many who feel that this limit has been about reached, if not entirely surpassed. In common fairness then, the schools should again study the question of what education is most worth while and which, therefore, should be provided at public expense. No one in this day and age, and least of all a school man, would be willing to advocate the denial of educational opportunity to any one, but if by better organization, by the elimination of unnecessary or duplicating effort, by the omission of those subjects whose cost is great and whose value is at the same time more or less limited by the nature of the subject itself and by the number of pupils pursuing it, better opportunities can be afforded all the pupils, it is the duty of those who are responsible for the administration of our educational systems to devote the time and thought necessary to accomplish these adjustments.

Another result of the changing industrial conditions of the times is the increasing part that science is playing in everyday life. The wireless telephone and the heavier-than-air-flying-machine—inventions which not so many years ago would have been regarded as epoch-making—are commonplace today. But not less striking are the modern applications of biology and chemistry in everyday life. It is, therefore, necessary that the average citizen should have at least an elementary understanding of the laws and principles which operate in the realm of these

various sciences. This means that time and place must be found for the introduction of science work in the elementary school curriculum, thus raising at once the question of what aspect of these various sciences should be taught, how much time should be devoted to their teaching, and what type of equipment, within the financial reach of the ordinary school and the capacity of the average teacher, should be made available.

The city school system places great emphasis on the social side of community development. Kindergartens are becoming universal, enabling little citizens to acquire social adaptation and control. With the bridging of the gap between the kindergarten and the primary grades, the more formal aspects of the kindergarten are being displaced and the gospel of gladness is permeating the primary grades.

The school system of yesterday placed all the emphasis on training. The self-made man who insisted that workers in industry or commerce should be trained only in apprenticeship and he who insisted that the school alone must prepare workers to enter industry were both wrong. The school can do its part in definite preparation; but that training should be supplemented by industrial or commercial institutions in order that knowledge through experience may grow into wisdom and power. This implies a distinct effort in vocational guidance. The adviser has come, not as a mere ferret, in search of special individual aptitudes; not as a necromancer or vocational fortune teller. He does seek to coordinate school effort; to make field surveys shed light on child employment, and finally, to establish contacts and articulation between the school and the workaday world.

The tremendous increase in the number of pupils and the shortage of trained teachers have made it necessary to employ hundreds, whose standards of professional preparation are below those of a dozen years ago. This fact emphasizes the problem of training in service which in some form or other is always with us, but which at the present time is more acute than usual. How can the results of modern research be made to function in the classroom? During more recent years, many investigations have been made to determine the steps by which the individual child learns to make certain specific responses to definite situations. One of the great tasks confronting all educators is to find the means to insure that the results of these

investigations are incorporated into habitual daily practice. It is one of our immediate tasks to make sure that this knowledge is disseminated throughout our schools, and that the principles and practices which are thoroughly established are made effective in our classroom teaching, for, after all, good teaching is the basis of all true progress.

If our schools are to fulfil the task given them, the citizen must be made not only economically or socially efficient—he must be trained in the proper use and enjoyment of leisure time. Art, music, and literature ennoble and enrich life, and their joys and pleasure must be constant possessions. Recreation should be a phase of definite instruction. Libraries, museums, and concert halls are filling an increasing place in civic life. More and more these activities are becoming identified with our public schools, and this work should be largely extended. To have a taste for good literature, fine art, and worthwhile music, to find pleasure in the competition of games, and to enjoy the wonders of the great outdoors insures an extended measure of happiness to the individual and increased tranquillity for the state.

Some means must be found for making available the experience of the teaching body when the superintendent of schools is considering educational plans and policies. To interpret democracy to children, teachers must themselves understand and appreciate the principles of democracy. To grow and do their best work they must see the large problems and the relation which their work bears to these problems. To plan wisely, the superintendent heeds the counsel of his entire corps. The teachers' council, rightly conceived, and administered as a help to the superintendent, has come to serve the schools.

Finally, the school system must be made to commend itself to the community. In a great metropolitan city the teachers, cooperating with the board of education and numerous organizations vitally interested in and friendly to public education, undertook the task of "selling the schools" to those most interested in the children. A three-year campaign resulted in 150 per cent advance in educational revenues. In a dignified way, the people have been induced to advance from a levy of fourteen million in 1919 to thirty-four million in 1922 for the education of their children. The average community is interested in its children; it is a part of the duty of a city system, as a professional organization, to lead the way, to interpret the schools to the community.

GRAPHS.

By Charles H. Sampson,
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More and more the subject of graphs demands attention as a department of the subject of algebra that needs to be stressed. Heretofore we have not given this mathematical method of indicating values the attention that it deserves. Neither have we realized the important place that it occupies in the field of those things that can be practically used.

Algebra is not always considered a practical subject and properly so. We do not use it as a whole in much of the work that we are called upon to do from day to day. It is not a practical working tool in the same way that other branches of mathematics are. It has, of course, other values that are of great benefit to the student; for example, that of mathematical mental exercise. But graphs differ from most of the other members of the algebra family in that the rules and principles that are used with them can be practically applied. There are very good reasons why we, as students, should understand how and why graphs are used. We must also realize that the study of them is worthwhile because of value of their use in many fields of everyday work.

One can easily understand the value of plotting methods (graphs) if he will use his powers of observation. Instances are everywhere evident of this. In every large city one may see practical applications of the use of graphs. In Boston, for example, on the "common" we have the daily temperatures plotted as the changes take place. The result is not merely temporary. The graph gives a permanent record of a large amount of information on a comparatively small sheet of paper. And best of all the record is in a form that is easily understood and in a form that is so compact that data for a long space of time can be filed away without occupying much room. There are many other examples of the value of graphs as a means of keeping in a satisfactory manner records of importance.

One can think of several of the things that we like to have recorded. Birth rates, as they change from year to year; averages in the stock market; production of material from day to day in a factory or manufacturing plant, etc. All of these and similar things may be compactly and completely represented by employing graphs.

The teaching of graphs is not so much a question of *how* as

when. The writer feels that the subject should be covered as a whole rather than by the "now and then" method so generally followed. It does seem wise to discuss the subject for a little while, drop it, and then take it up again at a period when the mental attitude of the student is apt to be different than when the subject was first discussed. The whole question simmers down to—"Is it not better to devote the first year of algebra study entirely to hammering on the fundamentals?" The job there ought to be that of building a firm foundation. Graphs may be given a little attention merely as a matter of interest, but to treat them too seriously at this stage in the course is somewhat of a mistake. They can be studied much more effectively later.

The pad method of studying graphs is the most practical and effective. Every sheet on these pads has an explanation at one side and a place for the solution of a similar problem at the other side. One is taught how to do a graph problem in a neat and accurate manner if the pad method is followed, and there is the added advantage of tying the explanation and the problem together.

When should the study of graphs be undertaken? The answer "the last subject covered should be graphs." The student has by this time learned all processes needed for their proper solution. He can then attempt them with some assurance that he will know what he is doing.

THE SETTLING OF PRECIPITATES BY CENTRIFUGATION.

By Walter O. Walker,
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The application of centrifugal force in settling of precipitates in liquids is by no means new. Advanced agricultural, biological, and chemical laboratories have made use of machines for centrifugation for a number of years.

However, the High School and even the college chemical laboratories have failed almost unanimously in recognizing the great amount of time saved in filtering processes by centrifugation. It is astonishing the little use made of the Babcock apparatus, and machines of a like nature.

Most High School chemical laboratories have in their equipment Babcock milk testing apparatus. By a simple modification, this tester can be changed to accommodate the average sized test tube. A cork is selected which will fit snugly in the top of the receptacle, which ordinarily carries the Babcock

bottle. The cork is then cut in two, parallel to its base. The smaller piece, after having had a small hole scooped out in its center to accommodate the bottom of the test tube, is placed in the bottom of the Babcock receptacle. The larger upper half of the cork is fitted in the top of the Babcock receptacle and a hole (large enough to admit the test tube) is bored through it. If the receptacles are all fitted in this manner, several test tubes can be accommodated at one time. The usual precaution with regard to a balanced load must necessarily be followed. The time saved in filtering processes for a class in one day will warrant the installation of this modified apparatus in any chemical laboratory. The method of operation is as follows:

The test tube containing the liquid and the precipitate is placed in the machine and properly balanced with another test tube of water or another test tube containing an equal amount of precipitate. The machine is rotated at normal speed. The length of time of rotation depends upon the nature of the precipitate. Barium sulphate, copper oxide, or any heavy precipitate requires about two minutes. A light gelatinous precipitate, such as aluminum hydroxide, requires about five minutes. A semi-colloid, such as arsenic, sulphide, requires more time and may not entirely be settled out by this process. In every case, the major portion of the precipitate settles out during the first minute of rotation. The additional time is necessary to clear up the filtrate (that which corresponds to the filtrate in the ordinary filtering process). For the average precipitate, the separation of precipitate and filtrate is as complete and satisfactory as in the old filtering process.

The points of advantage in the process are:

1. Time saved. The ordinary process of filtering is long and tedious.

2. A clear separation of filtrate and precipitate.

3. The precipitate is left in a compact form in the bottom of the test tube while the filtrate is poured off. This makes the process a great time-saver in qualitative chemistry.

4. Immiscible liquids which have become emulsified may be settled rapidly without resort to waiting for the natural gravity process.

The laboratory operation of this modified Babcock machine has proven its great value. Once installed it is of inestimable value. Two machines will generally accommodate the average laboratory section.

GEOGRAPHY AFTER FIRST YEAR SCIENCE.[1]

By I. N. Van Hise

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Introduction.

In the reconstruction of curricula, geography should be given a more prominent place among the subjects in the secondary school. There is an increasing and popular demand for more geography, but just what form it should take or what should be its content or when it should be given are matters of doubt or of dispute. These questions can only be solved by those who are teachers of the subject and by teachers of experience who study and understand the life of the child.

The Failure of Physiography.

Some geography in the form of physiography has been tried out in the first year of the secondary school and has failed. The failure has doubtless not been due so much to the geography attached to physiography, as to the fact that physiography is in itself a specialized science. Pupils of the ninth grade have not yet had the needed foundation in science principles. Then, too, the teaching of the course has frequently been given to a teacher untrained in the subject just to fill up a teacher's program or to accommodate a space in a working schedule of recitations. Many a skilled physiography teacher has met with the experience that the end of the term came after much of the time had necessarily been consumed in teaching physical and chemical principles and just as the real geography teaching was about to begin. In reality, the good physiography teacher was the pioneer in the so-called general science work. The earlier texts in physical geography devoted most of their space to establishing the physical principles of the science and only in their last chapter, headed by some such title as "Relation of the Earth to Plants, Animals and Man," did they come close to touching upon our present conception of geography. In this course, which was usually allotted only one semester of time, there was therefore crowded too much matter by far for any class of pupils to try to assimilate or for any teacher, either untrained or skilled, to try to cover. Results were, as might have been expected, unsatisfactory, but the feeling has well persisted that the child should have some science in the first year of the high school work. The teachers of the other and later sciences began to condemn

[1]Read before the Geography Section of the C. A. S. and M. T., at Soldan High School, St. Louis, Mo., November 26.

the work of the physical geography teacher and tried prescribing for the first year course from their own fields of science.

A Flood of New Books.

Often, without the value of recent experience in training the youngster fresh from the grammar school, teachers or former teachers have written books of predigested, peptonized, malted, or denatured physics and chemistry, and many of these books have been offered "for sale" in the past dozen years. To none of their subjects as much as to their science have the pupils entering high school loaned themselves for the purpose of experimentation. But some of these days, if that time is not now here, a more or less satisfactory textbook for the first year science course is going to be produced and it will not be a compressed physics or a boiled-down chemistry or a homeified biology, but it will give an unbiased view of the field of science that will serve as the foundation in understandable form for the interpretation of life. Note, I do not say either that it will be a geography, for geography may well come later.

Replacement of Physiography.

Among the reasons so often given to justify the replacing of physiography by a course in elementary or general science, there are some to which the geographer, the biologist, the physicist, and the chemist can all well subscribe. No one can recognize better than the physiography teacher that there are many boys and girls who enter high school and swell to overflowing the classes of the first year teacher, but who drop out of the race for an education before they have the opportunity to taste of the pleasures offered in the later years of the high school course. It is also admitted that the curriculum is so full, offering, as it well should offer, chances for liberal electives, that it is impossible for the pupil to get even a glimpse at the good things given in many of the later subjects which many others may elect to take. The great problem, then, for the framers of new courses of study is to determine what is best for the child, what subjects can be prescribed, and what subjects eliminated. A reasonable solution of this problem seems to be in the unifying of certain stem-courses for general information and training, such courses to be required of all pupils, and the providing of correlated electives along the lines of selected endeavor.

Planning of the First Year Science Course.

The cooperative planning of teachers of as many lines of science as possible would be advisable in deciding the make-up of the first year science course. These teachers should take a broad and unselfish view of the situation and suggest the basic science principles of which all of them could take advantage and upon which they could build their own later courses. Into this cooperation, the geographers should eagerly enter for there is scarcely a one of the sciences upon which they do not draw. They know how much it helps for pupils coming to them to have some knowledge of the simpler facts of astronomy, geology, physics, chemistry, and biology, and if the needed principles of these sciences are already even vaguely understood, a starting place or foundation may be found upon which to build interpretations. For is not geography a science of interpretation, as it seeks to find the answer to the "whys" of man and his labors? Geography should breathe life into the cold, dead facts of the sciences.

A New Course in Geography.

For some time now the demand for geography, or for more and better geography, has come from various sources, but little or nothing has been done. Even geographers themselves in meetings such as this have said "Yes, a course ought to be prepared"; our geographical publications print such advice as: "Standardizing high school geography would result in great good"; and committees have been set to work on the problem but have gotten nowhere so far as concrete advice is concerned. Our various modes of propaganda have been successful in creating the demand or establishing the call for geography, and the need of geography is admitted, but when we are asked what we are going to teach no one is able to answer the question. Something definite should be done by geographers or else we should not only cease asking for more time in the curriculum but should give way to other subjects and either quit the teaching business ourselves or turn our efforts into more established channels. What should we do? We, who are teachers of some form of geography, or who have been teachers of physiography, should answer the question and if we are to hold the field we should meet the needs by making the needed new course.

First, there are certain "powers-that-be" whose sanction must be obtained. We may call these the school administrators.

Some of these are already convinced that some sort of geography of a better grade is needed. With this much accomplished we need to go to them with some definite proposal. We need to show our goods and gain permission to try out and prove our plans.

The course must be evolved. It is in the making and we cannot show the finished product until, through trial and experience, we can from the great mass of geographical material and methods select what is best suited to our particular needs and weld these together into form.

The teachers concerned will have to do this work. Individuals have, and should have ideas, but no one or two teachers can see or solve the whole problem. If a group of enthusiasts in our subject, such as come together in our meetings like this one once or twice a year, could meet frequently and plan, then test out with actual classes, then confer again, I believe that by units the course could be best worked out. I know that the geographical distribution of those of us who are teaching limits such a plan, but wherever such groups could be formed they should get to work earnestly and, having the sanction or support of larger associations such as this, give to the rest of us the results they are able to achieve. A plan like this has been suggested in connection with seminar work in the summer terms of several of our universities and such a plan might well be considered. The university professor can be of valuable assistance in helping and advising in the selection of material, but I am not so sure that he understands the language and the methods by which the pupil of secondary school age must be instructed. The problem, I contend, is a secondary school problem and if solved will have to be solved with the aid of college, university, or normal school teachers assisting those actually teaching the high school pupils. The public school demands that its teachers have the scholarship and training afforded by the higher institutions of learning. Therefore the ability for such research work should be found among the high school teachers. The public school gives the practice opportunities but unfortunately, as we all know, the high school teachers are so crowded with classes and burdened with numbers of pupils that it is almost impossible for them to get any time for such constructive work as this situation demands. The public, though, is willing to pay for educational improvements when the need for them is shown Laboratories are equipped and kept running at great expense by school

funds, and the public treasury will provide maps and charts and globes and books and pictures and other illustrative material for advantage in the field of geography if we but show the uses for these essentials for our work. Yes, it may be that even time for us to pursue such preparations might be granted if the needs of the situation were properly presented. Is not the challenge of the task sufficient to warrant an effort along some such line? Are we going to gain ground for geography in the secondary school, or merely hold to what we have? Or shall we leave the subject entirely to the grammar schools and the colleges and universities without more satisfactorily bridging the gap in the secondary school? We must take some sort of a stand.

What the New Geography Course Must Be.

The world is smaller than ever before in that people are knowing and are wanting to know more about those of other lands. Geography is the source of such knowledge and geography must be more thoroughly presented in the schools if better and more sympathetic citizens are to be the product of the schools. It is time for us to quit wasting our time in our quarrels for position in the first year of the high school course and for us to make use of the First Year Science principles as a foundation and in the later years of the school work interpret for the pupil the scientific and social principles which have been either consciously or unconsciously adopted by the various peoples of the world.

The course must be a *new one,* a *worth while one,* and an *attractive one.* It must survey the previous experiences of the child and make use of these; it must try to provide what is needed by the youngsters to give them a broad and right view of men and nations; and it must work in well with the subsequent courses of their educational careers.

BUSINESS EFFICIENCY HAND IN HAND WITH SCIENCE.

Scientific work can be organized with the business idea of efficiency, and indeed the report made to Congress in 1878 by the National Academy of Sciences advocating the creation of the United States Geological Survey proposed as its ideal plan for a scientific bureau that which would yield the "best results at the least possible cost." Since then economy in science has become a still more pressing issue, and in the Thirty-seventh Annual Report an appeal was made to bureau chiefs and their advisers that the public scientific work should be properly coordinated, so as to avoid wasteful use of public money and to conserve scientific effort by preventing duplication both in research and in publication. Competition between scientific bureaus is as wasteful as competition between electric-light companies or other public-service agencies. The public can be best served by requiring each bureau inspecialized science to occupy its own field.

A FEW POINTS CONCERNING HIGH SCHOOL CHEMISTRY.

By Robert Fischer.

McKinley High School, St. Louis, Mo.

There are two points that I would like to consider very briefly. The first, not only applies to chemistry, but to other subjects as well. It is a general condition. I refer to the endeavor to over popularize school work, of trying to make education a pleasing process during which we endeavor surreptitiously, to slip one over on the pupil (if you will pardon the phrase), and give him a little education while he thinks he is having a good time. If the school is a preparation for life, then, it seems to me, we should endeavor to show the pupil life somewhat as it is. He must learn that there is no royal road to success, that he must work for every thing he wants and that the work is not always interesting and something new every day, but that, on the contrary, the work is often very much like drudgery and must be done, and done regularly, whether he likes it or not.

We see this tendency to popularize in many of the courses in which so-called home chemistry and chemistry of common things, really very difficult and much beyond the grasp of the beginner, is emphasized. The idea seemingly conveyed by the reading of these courses is that the chemically educated housewife, especially, can never be imposed upon when buying her household goods. When she buys meat, milk, preserves, etc., she will analyze them for preservatives. When she buys silks and woolens she will examine them to see how much tin or artificial silk she will have in her dress or how much shoddy or cotton there will be in the wool. When she buys butter she will determine the oleomargarine content, in coffee she will determine the amount of chicory, and in pepper the amount of ground cacoa nut shell and so on indefinitely.

Now we know that the graduate of the high school, who has taken a course in chemistry would never trust herself to do these things, even if she wanted to, and none of them ever want to. I very much doubt whether the teachers of these courses ever do it themselves, outside of the classroom.

In decrying this kind of false chemistry, I do not wish to convey the idea that these things should not be brought up in class for discussion. On the contrary, I believe they are important, they add interest to the work and will educate the people to

[1]Read before the chemistry section of the C. A. S. & M. T. at the Soldan High School, St. Louis, November 25.

understand and appreciate the value of science, and of chemistry in particular and will make them more capable and willing to cooperate with the authorities in enforcing laws having to do with food and general hygiene.

We should teach them the fundamentals of chemistry thoroughly, and incidentally bring out the relation of chemistry to their every day life, but we should not pretend to be able to make chemists out of them. That is impossible as well as undesirable in the high school.

And this brings me to the second point I wish to mention, viz.: The place of qualitative analysis in the high school. Personally, I do not believe that it has a place.

The purpose of the high school is to give a general education, to give a good foundation for further work, if further work is intended; to give the pupil an opportunity to look around; an opportunity to find out what botany, physics, chemistry, history, language and mathematics mean. In short, it should give him a chance to locate himself. Finally and most important of all, it should train and broaden the boys and girls who do not intend to go beyond the high school. It should teach them not so much how to make a living as how to live.

If we take this as the purpose of the high school I do not see how a course in qualitative analysis can be justified. One of the arguments that I have heard over and over from chemistry teachers in favor of qualitative analysis is that the pupils like it; that you cannot drive them out of the laboratory, that they are greatly interested in their work and that it builds up the course in chemistry. These points are all correct. The pupils do like it and are interested in it and put in all their spare time in the laboratory. Of course they do. A course in qualitative analysis for high school pupils is rather an easy course; it is mostly laboratory work; it is more or less a recreational hour and any pupil would rather be in the laboratory for a period than sit and study in his study room. The qualitative laboratory is a favorite place for boys—they feel grown up and big—they believe that they are almost at the pinnacle of chemistry. In short, they think they are chemists, an idea that is usually prevalent among boys who spend a good deal of time in the laboratory. As a matter of fact, they are not only not chemists, but are rapidly forgetting the little chemistry they ever knew. By giving a year and a half of chemistry, the third half being qualitative analysis, any teacher can soon increase the number taking his subject and

make it one of the most popular in school. I sometimes wonder if this is not one of the real reasons for teaching it in the high school.

When Liebig taught chemistry in Giessen the student learned how to prepare a few of the most important gases and then was started out on a course in qualitative and quantitative analysis. Liebig's course was translated into English in 1846 and from that time to 1888 it was practically the model on which all courses in chemistry in this country were based. The tradition of that course perhaps still lingers to this day in some quarters and is an additional reason for the presence of qualitative analysis in the high school.

Another argument advanced in its favor, one that sounds very good but is quite fallacious is that the United States is becoming more and more a chemical manufacturing nation and it is our duty, especially in large industrial centers like St. Louis, to train boys to take their places in these manufacturing plants as chemists' helpers or even as chemists. While this sounds well, it is, I think, incorrect. A boy's opportunity in one of these places would be ever so much better with a thorough knowledge of the fundamentals of elementary chemistry rather than with a smattering of elementary chemistry and of qualitative analysis. If he has a good knowledge of the fundamentals, the chemist in charge of the plant will soon teach him the routine work he has to do and the boy will have a good chance of understanding his work, and the chemist in charge will be delighted, I imagine, to find a boy who knows the difference between an acid and a base, what oxidation and reduction mean, who can write a formula or an equation, perform a few simple chemical calculations and who knows how to handle himself in the laboratory.

If we really wish to do something for this type of boy I would say teach elementary chemistry more intensively. I take it for granted that any study of the metals would teach the theory of qualitative analysis, and that is sufficient. Prof. Alex. Smith in his book on Teaching of Chemistry makes the statement that a knowledge of qualitative and quantitative analysis not only contributes but little to the pupils' knowledge of the main trunk of chemistry, but even diverts his attention from it.

It is from the brightest boys in school that the classes in qualitative analysis will be recruited. They liked elementary chemistry and they like laboratory work. At the end of their school

course, on account of their knowledge or supposed knowledge of chemistry, they are likely to drift into chemical plants, accept inferior positions and, due to their insufficient knowledge and training, will never have an opportunity for advancement.

On the other hand, if they had had but a slight knowledge, and knew it was slight but had become interested in the subject, they might have been fired with enough ambition to go to the university and acquire a thorough training in the subject. In other words, a little too much of the wrong kind of chemistry is liable to work an injury to the boy.

Then, too, the high school boy is too young to specialize. There is danger that too early specialization will interfere with his general development. He should have a taste of this, that, and the other thing.

I like to think of myself a boy again, just going to high school with the experience that I have accumulated all these years, and I ask myself what kind of a science course would I choose. Recognizing that the training in any one science is just as valuable as that in any other, I would, without any hesitation, most certainly take a year each of biology, physiography, physics, and chemistry, and would not specialize in any science at the expense of another. In this way I would be ready, as nearly as possible, either for the university or for life. If I went to the university. I would know which science I liked best. If I did not go to the university, I would have a general idea of each one of them. I am sure I would make a better citizen.

ONE-STORY BUILDINGS FOR CLEVELAND SCHOOLS.

Cleveland's newest school, the Miles Standish School, is of the new one-story type, and is as nearly fireproof and panic proof as any school in America, according to Cleveland school authorities. It has thirty-two classrooms, each with a direct exit to the yard. A great roofed court occupies the interior of the school. This is divided into playrooms, gymnasium, and auditorium, and every classroom opens into the court as well as into the outside playground. The court has higher walls than the classroom section of the building, and it is lighted by windows above the classroom walls. The building has no basement, the heating plant being in a separate structure in the rear. A central tower adds to the beauty of the architecture.

Cost of this type of school is said by Cleveland school architects to be less than that of two-story and three-story buildings for the reasons that basement, stairways, and upper floors are entirely eliminated and but eight per cent of the area is given to corridor space. In buildings of this common type about twenty-five per cent of the total area is given to corridor space. This school is the fourth of the one-story type to be built in Cleveland. Its cost was $875,000, but a similar structure could be reected for about $500,000 at the prices that now prevail.—*School Life.*

THE USE OF LOCAL MATERIAL IN GEOGRAPHY TEACHING.[1]

BY CLARENCE BONNELL,
High School, Harrisburg, Illinois.

The horizontal strata of the southern end of Illinois, at some period ante-dating glacial times, were subjected to an upbending process, which raised a rounded ridge extending from Cape Girardeau, Missouri, on the west to near Shawneetown on the east. This ridge has a width of from fifteen to twenty-five miles and crosses parts of Union, Alexander, Pulaski, Johnson, Massac, Pope, Saline, Gallatin and Hardin counties. On its western half, the north slope is more gradual than on the south and the highest points are nearer the south edge. The reverse conditions are true of the eastern half. Bald Knob, the high point in Union County, lies toward the south. Williams Hill, the highest point in Southern Illinois, is 1,065 feet high and lies in northern Pope County, just across the line from Saline County, not five miles from the lowlands of the Saline River, whose elevation is less than 360 feet.

In addition to the bending, numerous lines of extensive faulting occurred. Subsequent erosion of the ridge has reduced the original elevations by several hundred feet and has obliterated the differences of elevation due to slipping, except along the most prominent fault line. The sky line is generally even and the general position of the strata as exposed along the slopes and cliffs of the interior valleys is horizontal, or with but a slight dip. Local disturbances in the region of faults and folds, some of which extend nearly at right angles, cause a very abrupt elevation or fault cliff which extends northward from the east and west line of faulting.

Only the *lower* coal measures remain in the Ozark hills. Some thin seams of coal, outcropping in the hill-sides, supply fuel, locally. The main coal measures have either been eroded since being elevated or did not occur, due to elevation before upper carboniferous time. All along the north slope, in Gallatin, Saline, and Williamson counties, the thick coal veins, the Nos. 5, 6, and 7 veins, come to the surface at their southern limit. Slope mines are frequent here. All these veins dip deeper as they extend north and at a distance of a few miles from the out-crop are several hundred feet under the surface.

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[1]Read before Geography Section of the Central Association Science and Mathematics Teachers, at Soldan High School, November 26.

The Saline River rises in northern Johnson County and flows eastward rather sluggishly parallel to the ridge and near its edge. The tributaries from the south are short and precipitous. Those from the north are longer and flow through level country. The Ohio River is bordered by lowlands, especially on the Illinois side, from the mouth of the Wabash to the mouth of the Saline. Then suddenly it cuts right through the hills and exposes the rocks in a magnificent fashion. On the trip by boat from Shawneetown to below Golconda, the lowlands of the lower Bay Creek are reached. Bay Creek flows for seven miles out of the steep hills of Pope county, drops into an ancient river valley and flows eastward to the Ohio, in a sluggish course, that was once up-stream. Near where the Upper Bay flows into the low valley, Cache River, or one of its tributaries, arises in swamp lands, the Cache flows west. It and the bay occupy the ancient river-bed which lay south of, and parallel to the Ozark ridge, so close that its flood-plain, something like a mile or more in width, lies snug under the huge cliffs, which are a prominent feature all along the south edge of the hill range.

The old river-bed overflows when the Ohio River is high and even carries part of the water up Bay Creek and down the Cache in times of very great floods. Massac County, to the south, is a rich, rolling, farming region but slightly elevated.

The internal forces that reared the Ozarks from the plain were great and extensive. A volcanic neck appears in Hardin County, also the great Hicks' dome and numerous folds. The many fault crevices in this county are often filled with fluor spar. At Rosiclaire, the greatest fluor spar mines in the world are located and the almost vertical crevice, averaging six to eight feet wide, has been mined down to a depth of 620 feet. There is no apparent diminishing of the size of the vein or the quality of the mineral. Lead and some silver are mined with the spar. Iron ore of excellent quality, limestone of high grade, and very valuable clays have been exposed by the upheaval.

Harrisburg, the county seat of Saline County, located near its center, is about eight miles north of the Ozarks in the low lying territory to the north of the Saline River. Except along the creek bottoms, the land is generally rolling and well adapted to wheat raising. The bottoms are better adapted to corn. But farming is a secondary industry. Since 1900, the coal industry whose center is Harrisburg, has grown to great proportions, so that a community of 2,500 has grown to 15,000 in less than twenty-five years.

For nearly eighteen years, the writer has taught in the township high school at Harrisburg. The abundance of local material in the surrounding territory, especially to the south, led me to conduct a course in physical geography for a period of ten years, or more, based very largely on local material.

Local material is not necessarily such as is found in the school district. Anything that is within easy visiting range or even so remote as to be visited by but a few and by them rarely, may be considered local if it is within the cnild's home geographical experiences. By such experiences I mean those which he readily comprehends, because he can connect them with his own life. They should not be so remote, geographically, as to be beyond his mental vision. What his married sister's husband's father told him about how big the cypress trees grew down in the Cache River swamps is local geography, even though he never saw the Cache River, except with his mind's eye.

As a new-comer to the Illinois Ozark eighteen years ago, I had the same inquisitive outlook as the average school boy. Tales of caves, abandoned silver mines, bandits, horse thieves, wild pigeon flights, and a score of escapades, some true and some not, which were connected with the life of the early settlers, all came to me in due time. An interest in this human side of geography led to an acquaintance with places and people that has been the source of unmeasured pleasure both to myself and to others. During that earlier period of discovery of this region, then new to me, it was the interest in human associations that caused newly made friends and ardent young students to offer conveyance and companionship for many "a trip to the hills." Here is one instance: Stillhouse Hollow lies twelve miles away but in sight from our school windows. Why called *Stillhouse* Hollow? Traditions of a moonshiner's camp in this secluded place came drifting in. Then came the positive information that one of the old stones for grinding the corn for the still was still in existence. And, sure enough, it is there. And then the old "silver mine," a half mile away, in which an erratic easterner spent his small fortune in a hopeless venture. The "silver mine" is only a hole in the ground. But on the bluff above it, I discovered a few years ago, the old stone face, a real one, large and clear cut, that of an old, old woman. Strange to say, this had never been noticed before, yet located in territory that had been settled a hundred years. What an

opportunity to lead the imagination back! The southern limit of glaciation comes within a very few miles of this cliff. Mammoth skeletons are found in the Saline River bottoms, also in sight of this cliff. It is just across one county to the mound builders remains to the southwest. Indian graves lie on a ridge in sight across the valley and a lower ridge. Twenty-five miles to the east, Shawneetown, the home of the Shawnee Indians, is built upon the ruins of one or perhaps two prehistoric villages. Pottery, images, and utensils dug from its very site attest to this. Just across Stillhouse Hollow to the north, the bare face of the fault cliff shows the tilted strata as no picture in a text can show it. Starting with the upheaval which brought the stone face to the surface, the whole panorama of history, starting in the dim beginning of things still further back, and continuing on to the present day, with its hum of machinery and mines, can be put before the eyes of the soul-thirsty and mind-hungry youth. The coal age, the glacial period, prehistoric life, pioneer life, present day civilization, all these are here and in sight. I have led Saturday classes to this spot and there recited to them this synopsis of the history of mankind and they drank it in eagerly, because it was all connected with home materials.

The dipping strata seen so clearly from the cliffs just mentioned have served as material illustrative of mountain-making and development. Mountain-making by sharp upheavals of the earth's crust is illustrated here, yet, within sight of these cliffs, we find other hills just as high, whose strata are horizontal, but whose relative elevation is due to weathering. Such a place is "Wamble Mountain," a mesa-like plateau, whose somewhat level top has an area of some ten or fifteen acres. On nearly all sides, the walls are steep and inaccessible. All stages of weathering and under-cutting are illustrated. From all sides, the horizontal strata across the valleys correspond to those in the mesa, so that the view from its summit affords a text for several chapters.

Going back to the fault cliff, in which lies Stillhouse Hollow, we find high up near its northern point a limestone cave extending in, a quarter of a mile in each of two directions. The usual tales of bottomless pits and unexplored passages abound. While proven to be false, these tales never die. They are useful, because of the interest they add to the locality. Having made contact, the task of teaching caves and the effect of underground water in general is an easy one.

With interest aroused, and the imagination fired, it is an easy step to the limestone areas of adjoining counties. These are too far away for class visits, but pictures and descriptions are sufficient to make the right mental images. There has always been someone in the class who *has* seen the sink holes. From this use of local and semi-local material, what cave in the world cannot be understood? So it is with other features. Suppose we start right at home and see where we are led. Our school building, as do many others, stands on a ridge. Water from the west side of the roof flows to the "County Ditch" on the west side of town. Water from the east side flows to the east to "Pankey Branch." So we are on a divide. It has always been a revelation to learn that we might start from the class room and go to Chicago without crossing a stream. We have traced it out on the state map. The point is, that we started at home. Then divides anywhere in the world can be imaged. Again, we have used the Ozark hills of Southern Illinois for illustration.

In a like manner, stream action has been developed. Again we start at home with "Pankey Branch," "Briar Creek," or "Bankston Creek," all sluggish tributaries of the likewise sluggish Saline River. Then the short streams coming down to the Saline from the south are a part of our experiences—"Mud Spring Hollow" or "Beech Hollow" are in sight and some have visited them. Over in Pope County, Bay Creek falls over three hundred feet in seven miles and then scarcely flows at all, after entering the prehistoric river bed described above. The bay is too far away for class visits. Here again pictures and descriptions by those who have seen it can be fully appreciated. It has been my plan, to associate with any type study, all the beautiful and otherwise interesting details that the vicinity affords. About the Upper Bay Creek are the Belle Smith Spring, Clarida Spring, a natural bridge of a hundred fifty-foot span, a great sandstone cave large enough to seat a thousand people, the old Indian ladder, the mushroom rock, a balanced rock and overhanging cliffs of wonderful beauty and great geological interest. These are of great interest to anyone. The same forces, that have made upper Bay Creek a miniature of the upper Arkansas River, have had something to do with making all the setting mentioned above. They are a part of it, just as the Royal Gorge is an essential part of the Arkansas. Bare facts of river gradients or profiles should not be taught

without the setting that fixes attention and makes for clear imagery, whether the material is local or foreign to the child's experiences.

We will take a new start at home. As explained before, our school is in the great bituminous coal field of Southern Illinois. Of course fossil plants afford plenty of home material for a start. The story of a piece of coal is interesting. That is not all. A dike, completely cutting through the coal, lies directly under our school building. Slight faults and other dikes are frequent over the county. Many of the children know of their occurrence in the mines or, if they do not, a knowledge of them is of interest. From this starting point, there is no limit to the work that may be done with minerals, plains, submergence, elevation, erosion, and all the phenomena of crustal movements. Here, also, collections of local fossils, ripple marks on rocks, cross-bedding, etc., bring the sea far inland.

Beautiful scenery, interesting places of any kind—these should be utilized, wherever possible, in creating interest and stimulating the imagination. I once found three high school girls who lived in a city in Illinois on the Ohio River. They could bound Illinois or Kentucky. They remembered it literally. They could not point toward the Mississippi River or toward Tennessee or Indiana. If they had been carried on the wings of imagination from their environment to the Mississippi or Tennessee as students of geography they would not have failed to think the words they so glibly recited.

It may be said that my situation geographically has been unusually favorable. That is true. But I know schools just as near the Ozarks of Southern Illinois, in which the study of geography is as prosaic as it too often is in much less favorable situations.

DAILY RECORD OF CHILDREN'S HEALTH HABITS.

To follow up health instruction and to show its result in the formation of habits, a daily record of health habits is kept for every child in the schools of Washington, D. C. These blanks are marked after the morning daily inspection by the teacher. Each school day a mark is given for the pupil's observance of such habits as brushing the teeth, carrying a handkerchief, keeping good posture, taking thirty minutes' physical exercise, etc. Thirteen health habits are noted. At the end of a month a rating is given to correspond with the daily record, and the sheet is sent home folded around the report card, to be signed by the parent and returned. It is expected thus to secure the cooperation of the home in inculcating health habits. Children showing extreme neglect are referred to the school nurse.—*School Life.*

THE BIOLOGY TEACHER AND SEX EDUCATION[1]

By Benjamin C. Gruenberg

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One of the first demands that a community will make upon the teachers of special subjects is that they apply the principles of their subjects to their everyday problems, i. e., the boys and girls they have to teach. The teacher of biology, for example, must be expected not only to know the principles of ventilation, of fatigue, of the relation of exercise to digestion, of the relation of postural tensions of the skeletal muscles to the action of the viscera and to mental states; such a teacher must not only teach these principles to his students—he must make sure that the best working and living conditions for boys and girls are obtained as indicated by these principles.

We are not directly responsible for all of the difficulties and problems with which the boys and girls come to us in high school. We are not responsible, for example, for the fact that most children are neglected during the early years with respect to enlightenment on sex matters so that our introduction to the subject of sex comes on the average five years too late. We are not responsible for conditions in the homes and in the community at large that operate against the best interest of the children both from the viewpoint of physical health and from the viewpoint of mental health. But we are responsible for knowing what the conditions in the homes and in the community are, and we are responsible for adjusting our instruction and our guidance to meet the discoverable needs of the children, no matter what other community agencies do or fail to do. We must understand our social environment as well as our special subject if our teaching is to serve to its full capacity.

From the viewpoint of harmonizing his internal impulses with the demands and the limitations of his physical and social environment, the adolescent makes many diverse claims upon his "education." He needs first a daily program of activities that will make constructive use of his undirected energies; that will release the strains set up as a result of the internal secretions of the gonads and other physiological changes; and that will habituate him to socially acceptable modes of conduct. He may demand vital contacts with inspiring personalities and ideals

[1]Read before the New Jersey State Science Teachers Association, New Brunswick, October 29, 1921.

that will serve both to determine the form which his ideals and aspirations will take, and to strengthen his purposes and resolutions in meeting his problems day by day. He needs, further, guidance in interpreting the world about him as it operates through human passions, frictions and institutions. He is entitled, finally, to a common-sense acquaintance with the significant facts of life.

If other specialized teachers in the high school are to aid pupils in the interpretation of human relations—through literature, history, social studies—we must insure for them a foundation of knowledge on the part of the pupil which comes properly out of the biological studies. This is necessary if the discussions of these other teachers and their indirect allusions, in which so much of moral or social instruction consists, are to be of genuine value to the boys and girls. Whether our teaching is according to the type method, according to physiological problems, according to ecological or economic principles, the facts of sex cannot be escaped except by deliberate and violent distortion of our material. The teaching of morphology is impossible without taking into account reproductive structures and processes, whether in plants or in animals. A study organized about processes and functions which disregards those functions and processes that have to do directly or indirectly with the facts of reproduction is so obviously a fraud that even high school boys and girls are aware of the omission and frequently comment upon it. In the study of the relation between organism and environment there is nothing more striking or more significant than the adaptations for the perpetuation of the species as distinguished from adaptations for the survival of the individual. In the application of biological principles to economic problems both the structures and the processes related to reproduction come to be of prime interest. Even in the purely dilettante study of plants or animals for their esthetic possibilities, the flowers and other reproductive bodies, the distinctive plumage of birds and other secondary sexual characters acquire an outstanding interest.

The sequence in which various topics are taught is of minor importance. If we are teaching about organisms and if our teaching is organic, we find ourselves constantly repeating "topics" that have previously been studied in order to integrate each new idea with all that has gone before. No matter where we begin, sooner or later we must contemplate the organism

as a whole and the world of life as a whole. Somewhere in the course, therefore, each of the following topics should be touched upon, its implications made clear, its relations to other aspects of life established without ambiguity.

1. Development. The organism as we know it results from successive cell divisions with differentiation.

2. Origins. The single cell out of which the organism develops, originates from general vegetative cells or from specialized reproductive cells; and a reproductive cell may be sexual or asexual.

3. The universality of sex. In plants and in animals at every level of evolution sex is found. Moreover, the process of reproduction must be assimilated to the other processes and properties of protoplasm.

4. Parenthood and infancy. The transition from the externally fertilized and abandoned egg of lower forms to the internally fertilized and elaborately served and protected egg of mammalia, including man, and spermatophyta; the status of offspring after birth in the higher reaches.

5. Embryology. The outstanding features in the development of a vertebrate such as the frog or fish, with some reference to the analogous processes in the mammal. This is not so much to stress unduly the so-called law of recapitulation as to familiarize the pupils with the principles of development by progressive differentiation, and of the relationship between foetus and parent. The latter is especially important for counteracting widely prevalent and pernicious superstitions regarding "maternal impressions" and related aberrations.

6. Glands and gonads. The concept *gland* should be fairly clear from physiological principles studied; and the concept *gonad* should be clear from the study of reproduction, especially sexual reproduction and the origin of gametes. There is frequently confusion, however, when the attempt is made to teach internal secretions with special reference to the interstitial secretions of the gonads because the gonads themselves are frequently spoken of as "sexual glands." Strictly speaking of course the gonads are not glands since the products which they discharge are formed bodies (the gametes) rather than specific fluids. This confusion is serious because it leads in a large number of cases to identifying the spermatic fluid, for example, with the "internal secretions" with the result that the discharge of seminal fluid comes to be associated with "loss of manhood," and so adds unneces-

sarily to the anxieties of boys when they already have troubles enough.

The relationships between the internal secretions, of the gonads as well as of other organs, and the development of structural and functional characteristics, first, of the species as a whole (as certain intellectual and emotional qualities), and second, of the male or the female are both interesting and important. A study of these relationships can be made to impress upon the students a certain regard, not to say reverence, for these distinctive manifestations of our highly evolved species and of the highly differentiated sexes. The remarkable results of accidental, pathological or experimental castrations, and the results of the transplantation of gonads and of other endocrine organs and tissues have become an integral part of biological science as well as an indispensable part of applied biology and should by no means be omitted from the course simply because the usual text book or syllabus fails to mention them.

7. Secondary sexual characters. Their presence in both plants and animals and the great variety of forms which they assume in different types; the probable sources of secondary sexual characters in physiological changes, as distinguished from their possible adaptive significance. This topic is not only of great interest to young people but can be made a source of helpful guidance in the formation of ideals. In the course of the feminist movement it had come to seem necessary to emphasize the similarities between male and female in order to counteract the traditional emphasis on differences. But with the suffrage assured and with economic and social opportunities thrown wide open, it becomes profitable to re-examine the basic differences with a view to discovering significant possibilities for specialization. Having eliminated the invidious implications of earlier emphasis upon differences, it is now possible to draw attention to the positive, constructive forms of expression involved in these differences. It is just as true to say that girls can do things which boys cannot do as well, as to say that boys can do things which girls cannot do as well. It is recognized in education that we must help find for each individual that which he can do distinctively; we must also find what each sex can do most profitably. Moreover, a study of the secondary sexual characters lends itself very readily to the development of the idea that the higher organisms have available energies in excess of what is necessary for the maintenance of life. These energies find

outlet in structures and activities of a kind that distinguish each species from all others, and they are energies available in human beings for the highest types of activitiy that characterize the species. Our fine arts and our practical arts, our sciences and philosophies, can be shown to arise in considerable measure from these surplus energies made available by the internal secretions.

The subject of the secondary sexual characters, closely related to that of internal secretions, presents difficulties to teachers chiefly because we have not accustomed ourselves to thinking of the intimate interrelations within the organisms. In our own training the emphasis had been laid too much upon external adaptations in the Darwinian sense and in many cases in a teleological sense. But the simpler physiological process which we are already teaching can lead up very satisfactorily to these newer ideas. We know that chemical changes modify the action of protoplasm in a very striking way—as, for example, the increase in pulse rate resulting from a brief period of vigorous physical exercise. This familiar phenomenon is sometimes "explained" by saying that increased activity creates a demand for more oxygen in the tissues and that *therefore* the respiration and pulse rate are increased. When we come to think of this we see that the explanation obviously puts the cart before the horse. What really happens is that the increased activity results in the liberation into the blood of increasing amounts of carbon dioxid; and that the partial pressure of the carbon dioxid in the blood affects the nerves in the heart controlling the pulse rate and the respiration rate. In the same way our other studies have shown the effects of poisons, stimulants and narcotics as modifiers of feeling and behavior. It should not then be difficult to grasp the idea that certain specific bodies produce distinct modifications in the behavior of the various tissues and organs of the body even though these specific bodies are derived from the organism itself.

8. How we learn. The response of organisms to specific stimuli or to situations as a whole, and the processes by which the response is modified. Pavlov's experiments with the secretions of saliva and gastric juices in the dog furnish an excellent introduction to the study of conditioned reflexes, and this concept may be developed as a solid foundation for understanding how we came to substitute groups of stimuli, artificially or arbitrarily assembled, for the basic stimuli that naturally bring about a

given response. We can learn to have the mouth water on sound of the dinner bell. We can learn to straighten up when the word "posture" is mentioned. The importance of this study lies in two directions: It gives the student an understanding of the mechanism through which he may acquire that very much desired "self control" which he is constantly exhorted to exercise without being told how; and it gives him a better understanding of what we sometimes call "human nature" which he will need in adjusting himself to others and especially in his subsequent efforts to guide others, for example, his own children, in the formation of desirable habits. It goes without saying that an understanding of this mechanism is essential for the teacher.

9. Heredity and environment. Wherever the opportunity presents itself, students will invariably bring up the question of heredity and environment. Witn the basis of information concerning the various functions of the organism a study of fluctuations and modifications becomes possible. The Mendelian principles of segregation and unit character as shown in the phenomena of dominance, the idea of multiple factors, and that of the continuity of germ plasm are easily taught toward the end of the biology course even in the first year of high school.

In our inveterate disposition to preach we are often tempted to make of the study of heredity an occasion for impressing upon our students the responsibility of parenthood and to do so in a way that flatly contradicts our scientific teaching. On the one hand we teach the persistence of germinal factors that determine capacity; on the other hand we try to insinuate that the righteous life will insure superior progeny. This is, of course, sheer nonsense. What we may say is that those who have capacity for high grade living have it because of their heredity and manifest it because of their opportunities; and that they in turn will transmit such capacities to their offspring whether they have themselves manifested them or not. The most valuable implications, it seems to me, that the study of heredity carries for young people, is in the direction of opening the eyes to fundamental organic values, a cultivating, so to speak, of taste in organisms. We may perhaps teach young people to think of their future mates as the parents of their own children more critically than they might otherwise do.

Hand in hand with the study of heredity goes the inevitable question of the relative importance of heredity and environment. As usually formulated this question has, strictly speaking, no

real meaning. Two eggs in an incubator exposed to identical environment will yield respectively a Plymouth Rock and a White Leghorn. In both cases the unfolding of inherent characters depends upon a particular environment; a different environment would have inhibited the development of some capacities—would have stimulated the development of others. When we come to human beings our study of biology should make clear that there are certain fundamental conditions for normal development and that departures from or additions to these essentials of the environment modify development of the total inherent capacity in a way that is peculiar to each individual. There is no environment that is the best environment for all although there are certain things which every organism, more particularly every human being, must have in its environment if it is to develop favorably.

10. Venereal diseases. When we are teaching the elements of infectious diseases, gonorrhea and syphilis with their more pronounced symptoms and consequences may be taught along with tuberculosis and diphtheria and typhoid fever, etc. After the principles of reproduction have been taught, the venereal diseases as such, that is to say in their relation to the most frequent mode of transmission, may again be introduced from the viewpoint of prevention and from the viewpoint of their more serious racial consequences.

11. Personal problems. Varying with the composition of the class and with the personal relation between pupil and teacher, a multitude of other questions will arise that have a proper place in biology instruction, although they may not be uniformly part of the biology course. Among these questions are the facts and meaning of menstruation and seminal emissions; or the problems of so-called "sex necessity" and masturbation. These questions can never be handled satisfactorily in mixed classes of high school age and probably not in classes at all by most teachers. Yet the individual student should certainly have an opportunity to have his questions answered and in many cases the biology teacher is the only one equipped to meet the situation and will, therefore, have to find opportunity outside of class.

In the teaching of science we must be confident that the truth needs no bolstering. There is need for neither exaggeration nor minimizing of statistical data or of clinical facts. The pushing of a moral with too much vehemence is likely not only to arouse hostility of pupils, but also to arouse suspicions as to

the validity of the argument. The scientific temper means not only that we make pupils consider all facts without prejudice, but that we as teachers be always ready to consider new facts and new interpretations of old facts. We ask our pupils to be open-minded and objective; if, instead of asking them, we demonstrate these attitudes day by day for a reasonable length of time, we shall be spared the need of asking them, and probably get better results. We must realize that the value of science—or knowledge—is not in making us do things, but in showing us an ever better way of doing what we already wish to do, and better things to desire. Its great intellectual contribution is in making its followers hold fast to what they have, always subject to revision—in giving us the experimental outlook upon the problems of life—in habituating us to accept truth as always tentative, a working hypothesis, and our beliefs as constantly growing and refining, not as final doctrines to be forced upon all who come under our domination.

CONTESTS TEACH CHILDREN SAFETY.

Reduction of automobile accidents and fatalities among school children already are beginning to be apparent as a result of the national safety contests conducted by the Highway and Highway Transport Education Committee, according to reports emanating from all sections of the country, it was said here today by officials of the committee..

"We observe a decided tendency toward carefulness," writes one school superintendent. "It is unlikely that the principles of safety could have been impressed more firmly upon the minds of our pupils in any other manner than by means of the contest conducted under your supervision."

With the contests over, the next task, according to the committee, is the grading of the manuscripts and the awarding of the 472 state and territorial prizes and the national honors and prizes offered for the best essays and the best lessons prepared in the contests. Correspondence with school officials from all sections of the country indicate that a veritable deluge of essays by pupils and lessons by teachers are reaching the offices of the superintendents and principals.

"We feel keenly the responsibility that devolves upon us to see that each manuscript written receives careful consideration." say officials of the committee. We are receiving splendid cooperation from county, city and state superintendents of schools."

As a result of the campaign conducted by the committee many inquiries are being received regarding the best means of caring for local conditions. These requests come from Tennessee, Michigan, California, and other states. It is believed the committee eventually will become a clearing house for safety ideas, disseminating them to all persons interested in the protection of children from motor mishaps.

It is said that the results of the contests can not be known before March or April. At that time a general announcement will be sent out to all schools and persons interested, and to the press.

THE BIOLOGICAL SCIENCES IN MINNESOTA HIGH SCHOOLS.

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What is being done in the biological sciences in the high schools of Minnesota? To determine this point, a questionnaire was directed to 165 of the 240 high schools of the state during the spring of 1921. The purpose was primarily to secure information for guidance in organizing a teachers' course in zoology. The questionnaire included detailed questions relating to zoology and general biology, and less specific questions concerning botany and physiology. A few questions concerning general science were also included, since a small amount of biology is also included in that subject. Concerning these subjects, it was desired to know the attitude of educators of the state, what the demands were, what developments, if any, were taking place, and how the subjects were being conducted. 109 of the 165 questionnaires were returned with the information desired. These came from schools of all sizes ranging from a high school enrollment of 48 to that of 3,078, the greater number coming from schools of less than 500 enrollment. In order to inform those of the state who are interested as well as others who might wish to know something about the status of the biological sciences in Minnesota, a review of the facts obtained is herewith given.

General Situation.

By examining Table I, it will be seen that general biology, zoology, physiology, and botany are practically the only purely biological subjects taught. One school reported a course in sanitation.

Table I.

Table I shows the high schools heard from, arranged according to enrollment and showing the subjects offered in each high school. "X" indicates the subjects given and the dashes indicate those not given. The enrollments marked with an asterisk are taken from the state high school inspector's report for 1919-20, since some neglected to report the enrollment in the questionnaire.

No. of high science Zoology	No. of high science Zoology Location school Gen. Botany	Location school Gen. Botany		Enrollment Gen. biology Physiology		Enrollment Gen. biology Physiology	
1	Kasota	48	X	—	—	—	—
2	Bird Island	50	X	—	—	—	—
3	Morristown	50	X	—	X	—	X
4	Lyle	53	X	X	—	—	—
5	Adams	56	—	—	X	X	X
6	Rushford	58	X	—	—	—	—
7	Howard Lake	60	X	—	X	—	—

8	Cass Lake	63*	X	—	—	X	X
9	Henderson	65	X	—	—	—	—
10	Cottonwood	65	X	—	—	—	—
11	Morton	70	X	—	—	—	—
12	West Concord	70	X	—	—	—	—
13	Roseau	70	X	—	—	X	X
14	Red Lake Falls	70	X	X	—	—	—
15	Hawley	71	—	X	—	—	—
16	Lake Park	73	X	X	—	—	—
17	Sherburn	74	—	—	—	X	X
18	Fertile	74	X	—	—	—	—
19	New Richland	75	X	—	X	—	—
20	Annandale	75	X	—	—	—	—
21	Mt. Lake	80	X	—	—	—	—
22	Heron Lake	80	X	X	—	—	—
23	Warroad	83	—	—	X	X	—
24	Waterville	84	—	—	—	—	—
25	Dodge Center	85	X	—	X	—	—
26	Hayfield	85	—	—	—	X	X
27	North St. Paul	85	X	—	—	—	X
28	Blooming Prairie	90	X	—	X	—	—
29	Minneota	95	X	—	—	—	—
30	Barnesville	95	—	—	—	—	—
31	Monticello	104*	—	—	—	—	—
32	Zumbrota	108	X	—	—	—	—
33	Breckenridge	110	—	—	X	X	X
34	Preston	110	X	—	—	—	—
35	Sleepy Eye	110*	X	—	—	X	—
36	Fosston	110	X	X	—	—	—
37	Wells	110	X	X	—	—	—
38	Springfield	112	X	—	—	—	—
39	Harmony	115	—	—	—	—	—
40	Rush City	117*	—	X	—	—	X
41	Excelsior	117	—	—	—	—	—
42	Spring Grove	120	X	—	—	—	—
43	Renville	121*	—	—	—	—	—
44	Winnebago	123	X	—	X	X	—
45	Granite Falls	123	X	—	—	—	X †
46	Glencoe	125	X	—	—	—	—
47	Farmington	130	X	X	—	—	—
48	Hinckley	130	—	X	—	—	—
49	International Falls	131*	—	—	—	—	—
50	Pelican Rapids	133*	X	—	—	—	X
51	Elbow Lake	135	X	X	—	—	—
52	Ortonville	138	X	X	—	—	X
53	Cannon Falls	140	X	—	—	—	—
54	Buffalo	150	—	—	—	—	—
55	Tracy	156	X	—	X	—	—
56	Dawson	156	X	X	—	—	—
57	White Bear Lake	160	X	—	—	X	—
58	Kenyon	162	X	X	X	X	—
59	Princeton	165	—	—	X	—	X
60	Warren	165	X	—	—	—	X
61	Long Prairie	165	X	—	—	—	—
62	Blue Earth	170	—	—	X	—	X
63	Aitkin	170	X	—	—	—	—
64	Waseca	170	X	X	—	—	—
65	Staples	175	—	X	—	—	X
66	Luverne	175	—	X	—	—	—
67	Glenwood	176*	—	—	—	—	—
68	Madison	177	—	—	X	—	—
69	Windom	185	X	—	—	—	—
70	Canby	186	X	X	—	—	—

71	St. James	196	X	—	—	X	X
72	Gilbert	200	X	—	X	X	—
73	Litchfield	205	X	—	—	—	—
74	Lake City	210	X	—	—	—	—
75	Marshall	215	—	—	X	X	—
76	Redwood Falls	221	X	X	—	—	—
77	Worthington	223*	X	—	—	X	—
78	Hastings	225	X	—	—	—	—
79	South St. Paul	250	X	—	—	—	—
80	Detroit	250	X	—	—	X	—
81	Bemidji	275	X	—	—	X	X
82	Moorhead	296	—	X	—	—	—
83	Alexandria	300	—	—	X	X	X
84	Grand Rapids	300	—	X	—	X	X
85	Anoka	305	X	—	X	—	—
86	Brainerd	311	X	—	X	—	—
87	Willmar	315	X	—	—	—	—
88	Crookston	315	X	—	—	X	X
89	Rochester	316	X	—	X	—	—
90	Ely	316	—	X	—	—	—
91	Little Falls	325	—	—	X	—	—
92	Owatonna	335	X	—	—	—	—
93	Chisholm	344	X	X	—	—	—
94	Northfield	350	—	—	X	X	X
95	Red Wing	336*	X	X	—	—	—
96	Montevideo	365	X	—	—	X	—
97	Albert Lea	400	X	—	X	X	X
98	Eveleth	450	—	—	X	X	—
99	St. Cloud	451*	X	X	—	—	—
100	Hibbing	580	X	—	—	X	—
101	Winona	700	X	X	—	—	X
102	Denfield H. S., Duluth	800	—	X	—	—	—
103	Johnson H. S., St. Paul	828	—	X	—	—	—
104	Mechanic Arts H. S., St. Paul	1300	—	—	X	X	X
105	East H. S., Minneapolis	1650	X	X	—	X	—
106	West H. S., Minneapolis	1647*	X	X	—	X	—
107	North H. S., Minneapolis	2200	X	X	—	X	—
108	South H. S., Minneapolis	2200	X	X	—	X	—
109	Central H. S., Minneapolis	3078*	X	X	—	X	—

However, no school gave all of these subjects. Furthermore, there was no uniformity in the selection of the subjects for the curricula, some selecting one combination and some another.

Table II is a summary of the chief facts shown in Table I. An examination of Table II shows that of the 109 high schools heard from, 9 (8%) reported no biology of any kind. 26 others

Table II.

Table II is a summary of Table I, showing the number and per cent of schools offering no biology at all, those offering biology of some sort, and those offering each of the various biological sciences usually taught in high school.

Gen. Science	Gen. Biology	Zoology	Botany	Physiology	Total giving biology besides gen. science	No biology at all, or only gen. science	Total schools reporting
76 schools	**33**	**25**	**31**	**25**	**74**	**35**	**109**
70%	**30**	**23**	**28**	**23**	**68**	**32**	**100**

(24%) gave only the little biology occurring in general science, an amount not worth mentioning. So it may be said that 35 schools (32%) had little or no biology in their curricula. The remaining 74 schools (68%) offered courses in biology in some form or other.

General Biology.

One of the most interesting facts noted was the increasing popularity of general biology. It is finding its way into the high school curricula by leaps and bounds, and is equally popular with small and large schools. According to the report of the state high school inspector, less than 9% of the high schools of the state offered the subject in 1919-20 (see Table III). The past year, 30% of the high schools heard from reported it in their curricula. A great many more signified their intentions of introducing the subject in 1921-22 or soon, so that the per cent mentioned above will be greatly increased. This growing popularity indicates that general biology is filling a long-felt

Table III.

Table III is intended to show the trend of each of the biological sciences (including general science) since 1904. Figures for physics and chemistry are also included for comparison. The figures given are in per cent. The first four columns of figures were computed from information received from the state inspector of high schools directly and also from his official report for 1919-20. The last column was compiled from facts obtained in the questionnaire. The figures in this column are also found in Table II.

Subject	Per Cent of schools pursuing subject				
	1904-05	1914-15	1918-19	1919-20	1920-21
Gen. science	.....	8	45	50	70
Gen. biology	....	....	6	9	30
Zoology	37	40	31	28	23
Botany	49	62	49	47	28
Physiology	60	54	56	50	23
Physics	71	67	61	66	?
Chemistry	58	71	75	70	?

demand among educators for a general course embodying the fundamentals of all the biological sciences with much of the details and technicalities omitted.

There is a decided preference expressed for general biology over the usual courses given in zoology or botany. Some of the reasons mentioned for this preference follow

1. General biology is a course embodying the essential of all the biological sciences with much of the detail left out. Hence,

2. Greater economy of time and teaching force in the crowded curricula of the smaller schools especiallly.
3. Since the life processes are fundamentally the same in plants and animals, this fact can be better shown in a general course.
4. Greater correlation between the various biological sciences can be effected through a general course.
5. General biology is practical, broad in its scope, and less technical than either zoology or botany, and therefore better adapted to high school work.

However, general biology was also criticized on the following points:

1. It is too generalized, vague in content, and lacking in concreteness.
2. It is apt to be merely a snap course in the hands of a poorly prepared teacher.
3. It is often poorly organized.
4. While a fair idea of life processes may be obtained, an adequate idea of the plant and animal life of the community is hard to obtain because the course is too brief.
5. As an introductory course to more advanced work, or as a short course, it is good, but as a complete and all-sufficient course it falls far short.

General biology is most commonly given in the tenth grade. It is a year course. It is optional and given every year instead of in alternate years. The number of laboratory periods per week vary from no regular period (i. e., the laboratory work is inserted whenever and wherever convenient) to two double periods.

The preference in textbooks centered in Gruenberg's Elementary Biology. G. W. Hunter's Essentials of Biology and his Civic Biclogy have also been adopted to quite an extent.

ZOOLOGY.

By examining Table III, it will be seen that zoology enjoyed a fair amount of prominence in the high school curricula up to 1914-15. Since that time, there has been a steady reduction in number of schools offering the subject. Even since 1919-20, there has been a reduction from the 28% that were giving the subject that year (see Table III) to 23% that gave it last year (see Table II). There were indications that the per cent will be further reduced owing to the fact that zoology, together with botany and physiology, is being replaced by general biology in many places.

Evidently zoology has not been adapted to the demands of school administrators in the past and, therefore, is failing. It was thought by some to be too technical, specialized, and detailed for high school students. It was also criticized for its lack of practicability and its inclusion of too much material that is not of any benefit to the average student. However, there

are those who defend the subject and believe in its retention as a subject of real value in the curriculum.

Zoology is given usually in the tenth grade. It is an optional subject exclusively. In the smaller schools, it is usually given every other year, alternating with physiology or botany. Where the curriculum allows it, two double periods of laboratory work per week is the favorite arrangement. The subject matter emphasized is the economic and practical phase of the study, the habits and life processes of the various animals studied, together with some morphology.

A number of textbooks were mentioned. Colton's Descriptive and Practical Zoology was reported more than any other book. Others mentioned were Davison's Practical Zoology, Hegner's Practical Zoology, Linville and Kelly's Textbook in General Zoology.

Other Biological Subjects.

Another prominent development noted is the growing popularity of general science. It has been increasingly prominent since its introduction and is still on the upward path. In 1919-20, 50% of the high schools of the state were offering it (see Table III). According to information given in the questionnaires, 70% of the schools offered the course last year (see Table II). It is usually given in the ninth grade, is a required subject exclusively, and a year course.

Botany is suffering the same fate as zoology. It has always held a greater prominence than zoology but like zoology is at present losing ground due, to a great extent, to the encroachment of general biology. In 1919-20, 47% of the high schools offered botany (see Table III). The past year, only 28% offered the course. Botany is subject to the same criticisms as zoology.

Even physiology is losing its prestige. A drop from 50% to 23% has been effected in the past year. (See Table III.)

The reduction in number of schools offering zoology, botany, and physiology is no doubt due to the rapid rise in popularity of general biology. Some of these subjects are being removed from the curricula in order to give place to general biology. This change is occurring mainly in the smaller schools. In the larger ones, general biology is merely one of the biological subjects given.

General Discussion.

The presentation of the facts obtained from the questionnaire has been the main consideration up to this point. Personal

opinion has been studiously avoided in order not to confuse it with facts as reported in the questionnaires. But perhaps the humble opinions of a biology teacher with high school experience might not be amiss here.

When viewed from the standpoint of the number of schools giving biology in some form, the situation on the surface is not alarming, since the per cent of schools offering some form of biology (68%) measures up well with the per cent for other sciences. However, there are certain facts and tendencies that need serious consideration. It is to be regretted that as many as 32% of the high schools heard from should fail utterly in seeing the value and necessity of biology to high school students. In these days, the public is clamoring for the practical in high school curricula. What subjects are of more practical value than the biological sciences? Surely, to familiarize high school students with the plants and animals of their own community—a part of the environment with which they come in contact every day—to teach them the fundamental facts of life through a study of the life processes of plants and animals, and to teach them how to live, themselves, is of utmost practical value. To teach students to use their hands and make a living is practical, but of what use is this to them if they know not how to care for their bodies and to keep fit? Efficiency in work depends upon efficiency in living. This is a well established fact. Hence, the study of biology is fundamental and deserving of first consideration in preparing students for earning a livelihood. Not only should biology be given in every high school in the state, but it should be required of every student.

The rapid rise of general biology has been pointed out. Evidently this subject is filling a long-felt want for a general, practical, and untechnical course covering the whole field of biology in one year. It has proven a boon to the smaller schools with their problem of the crowded curriculum, since the whole subject of biology is treated in this one course. The fact must not be lost sight of, however, that general biology is only an elementary course and by no means an adequate one where it is possible to give more. A sufficient knowledge cannot be obtained of the plant and animal life of a community, of physiology, hygiene and sanitation, and fundamental processes of life, all in one year. The subject is a good, short course for those who are taking vocational courses and whose selection of the regular academic courses is limited. It should be required of these students.

But for those who are taking the regular academic work, a course in general biology is too meager; for these students, the usual courses in zoology, physiology, and botany are preferable and should be available. And at least some of them should be required.

The decrease in demand for zoology, physiology, and botany is to be regretted. The charges brought against these subjects seem to me unfounded. They are due to several causes: (1) The teachers themselves are largely to blame for the criticisms heaped upon the subjects. Their lack of sufficient preparation and consequent poor pedagogy, and their failure to see and appreciate the needs of the community and to adapt the courses thereto, have caused much of the criticism. (2) Many school administrators lack a knowledge of the biological subjects and are therefore unable to see the possibilities in them. (3) Mollycoddle ideas of education today demand a removal of technicalities and details from the subjects so that the courses are made very superficial, shallow, and inadequate. Those who entertain these ideas furnish much of the criticism of zoology and the other special biological sciences.

To say that zoology, physiology, and botany are impractical is a huge mistake. In the hands of a wide-awake, well-prepared teacher, they can be made just as live and applicable to daily life as any subject in the curriculum. Zoology and botany are studies of the living things of our environment. We are constantstantly coming in contact with these living things every day of our lives. This daily contact should be a strong argument for the practical nature of these subjects, just as the daily use of English is the oft-repeated argument for the practical value of that subject.

The study of plants and animals of the community only, a study of local pests and their control, the knowledge of the fundamentals of our own lives as learned through a study of the life of plants and animals, are all points of practical worth. Other points might be mentioned here to show the value of zoology and botany from the practical standpoint, but space does not permit further elaboration.

Can anyone doubt the practical value of knowing one's own body and how to care for it? Is it more necessary to know the operation of an engine in an auto, or how to operate a lathe, or how to construct a library table, than to know the mechanism of the human body and how to take care of it? Or is it more

necessary to teach high school students, through the study of agriculture, to care properly for the sanitation of cattle and hogs, and to prepare the soil properly for the sowing of clover, than to show them how to keep proper sanitation in their own habitation? Judging by the slump in interest on the part of school administrators toward physiology, hygiene and sanitation, one would be led to conclude that there are altogether too many who think thus. One needs only to visit the homes in one's own community to see the lack of knowledge of the principles of hygiene and sanitation and the need of more education along this one line. A good, solid course in physiology, sanitation and hygiene is not only practical but necessary and cannot be replaced by such a short course as general biology.

Some assail zoology and the other special biological sciences because of their so-called technicality. It is true that these subjects can be made very technical, or, much of the technicality can be omitted within certain limits at the discretion of the teacher. It would, of course, not do to transplant a college course in zoology to a high school because of the technicalities of such a course. The subject must be adapted to the age and need of the high school student. If zoology has failed in this in the past, it is because of the failure of the teachers in adapting the subject to high school needs, and not to the subject itself.

I have mentioned a very few of several criticisms that have been offered against zoology, botany, and physiology. On final analysis, the failure of these subjects is not due to the inherent nature of the subject matter, but to impractical, unadaptive pedagogy on the part of the teachers and to misconceptions as to the value of the biological studies by high school authorities. Any subject is just what the teacher makes of it. It is my opinion that the biological subjects have been unjustly criticized because of their contents, whereas the blame should have been placed in many cases on the teacher.

Much more could be said in defense of the special biological sciences. But better and more complete discussions on their value have appeared in former numbers of School Science and Mathematics. The purpose of this discussion was mainly to present the facts obtained in the investigation of conditions in Minnesota, but I could not refrain from expressing some of the opinions that suggested themselves in passing.

SQUARE ROOT OF A LINE WITHOUT USE OF THE CIRCLE.

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The unit parallelogram has been neglected by mathematicians. I have not seen it in any modern textbook. Sir Oliver Lodge in his *Easy Mathematics* (by the way—is there such an animal?), says something almost on the lines of it. His thought is (this is not a quotation but my expression of it) $x^2+2ax+a^2$ is an area, the square on $x+a$; so x^2-2x+1 is an area, the square on $x-1$; it seems as if a line was added to an area and twice a line subtracted from it. But it isn't so—$2x$ is a parallelogram: $x(2)$, 1 is a square $1^2 = 1(1)$. So, if he had further noticed (and said) x^2 is the parallelogram $x^2 1 = xx$, he would have introduced the unit parallelogram to mathematical teaching. There is another idea which in a sense is introductory to the unit parallelogram. That of the equality of what may be named cross parallelograms.

It is, of course, understood that Euclid is "Victorian" and as much out of date mathematically as Wilkie Collins or Anthony Trollope in fiction. But for all that, as my geometry was learned more than fifty years ago, the credit must be Euclid's 43, 1.

To Euclid is also due the geometric relations expressed in the algebraic equation due to Descartes, $y^2 = 2rx-x^2$. (Sir Oliver Lodge uses this numerically in his *Easy Mathematics*). It is evident that the square on y equals the parallelogram whose base is $2r-x$, altitude x. If x here is 1, we have the unit parallelogram $(2r-1)1$. Now given a line its square root may be found by drawing the circle, $2r$ the diameter, etc. The vertical y standing on the line at 1 inside the rim is "found" by the circle arc.

We have it in hand now to show how x as the square root of $x^2 1$ may be had without use of the compass. Here, before proceeding, is the place to apologize for a slight inaccuracy in language. The parallelograms are in strict scentific phrase rectangles. The other word has been chosen as more significant, in fact; the parallel feature being the important thing for the mathematics.

Algebraically putting $(1+dv) = x$, $x^2 = 1^2+2dv+(dv)^2$, (d^v, difference in the vertical between 1 and x). Geometrically this is the unit paralellogram $x^2 1$ which is made up of $1^2+dv1+dv1+(dv)^2 1$. And we see that $x^2 = xx$ is made up of them, noting that $dvdv$ or $(dv)^2 = (dv)^2 1$. But, of course that exposition takes dv as known, whereas outside of the $1\times 1 = 1^2$, we do not know how $x^2 1$ is divided. The critical or deciding point for the pur-

pose (of finding dv) is at the distance of 1 from the vertical of the isosceles, base x^2, its toes so to speak at angles of 45° to it; as it cuts the upper side of the unit parallelogram. Through this point draw parallel to the right side of the isosceles, which meets the left side (at rt. ∟s). The vertical from this determined point, to the base x^2, is x. And, as Bhaskara, if alive, would say, "Behold." For the rest of the figure, to prove $(dv)^2 = (d^0)^2 1$ draws itself. Unless our written description is too blind, the drawn figure complete should have two letter A's,one the isosceles base x^2, the other the isosceles base $2x$. And the diagonal of parallelogram $x(x^2-x)$ from the foot of the square of x should pass through the critical point.

As a corollary $x^2x = x^3$. Note that $x(x^2-x) = x^3-x^2$; that is the square on x subtracted from the total parallelogram $x^3 = x^2x$, yields the total parallelogram, vertical x, base the difference, x^2-x, as lines.

Also note $(1+dv)^3 = x^3$. This is proved by showing $1^3+3dv+3(dv)^2+(dv)^3$ can be built into $x^2x = x^3$ without drawing any additional lines. There are $3dv$1's, and as to $(dv)^3$, $(dv)^2 1 = (dv)^2$ therefore $(dv)^2$ is the line as the base of $(dv)^3$, which is $(dv)^2 dv$.

We remark on this, from x^2 we derived x, and from that, x^3. But if we start from x^3, we do *not* get x^2 or x by locating dv, etc. At least the writer has spent a great deal of time over the matter without success.

For, in fact, this is to find the cube root of a line with ruler and compass, and has been shown impossible.

But if we go a different way to work and call to our aid a fact discovered by the calculus we can do so.

We select as our algebraic guide the equation of the cusp curve, the 2/3; which in the x form is: $x^2 = y^3$, $x^{2/3} = y$. Whence the ratios $x/y = x^{1/3}/1$, $x/y = y^2/x$. So that $x1 = x^{1/3}xy$ and $3/2\cdot x/y = 3/2\cdot x^{1/3}/1$. From the calculus the subtangent, of the curve is $3x/2$. Drawing y as vertical at the end of x and 1 as vertical at the end of $x/2$ (i. e. as cut off by the tangent line from the end of the line $3x/2$ to the top of y) we have the geometrical ratio $x/2_1 = 3x/2_y$.

Therefore, if we start with parallelogram $x1$ as given, x base 1 vertical; add $x/2$ to x (continued to the left), draw as a tangent from the left end of $3/2x$ through top of 1 to meet the vertical from the right end of our base line we shall have $3x/2$ as subtangent, and the vertical is y, in the curve $x^2 = y^3$. Whence the ratios mentioned can be shown geometrically

We should add some lines—vertical and diagonal, for parallelogram xy; vertical $= y$, where the diagonal crosses the top line of parallelogram $x1$.

As $x/2/1 = 3x/2/3 = 3x/2/y$, $y = 3$. As $x/y = x/3$ and $x/y = x^{1/3} \ldots x/3 = x^{1/3}$. That is; we have apparently obtained the cube root of the line x.

But here it is to be said, this cannot be true in an arithmetic sense. True we *started* with x and 1 and have developed the curious results: $y = 3$, $x/3 = x^{1/3}$, from the algebraic geometry and the subtangent. But algebra and geometry show the 1 not to be arithmetical, and y is not 3.

Our x/y above $= x^{1/3}$ therefore $x = x^{1/3}y$ that is, x is "so many times" y. Suppose $x^{1/3} = {}^{2/3}$, $x = {}^{2/3}y$, but $y = x^{2/3}$ $=$ square of $x^{1/3}$, $x = {}^{2/3}\times{}^{4/9} = {}^{8/27}$.] [And ${}^{4/9}$ is not 3. Again $x^{1/3} = 10$ $x = 10\times100 = 1000$. And the cube root of x is 10 not $333\frac{1}{3}$, and $y = 100$ which is not 3.

There are three regions of the curve:

(a) $x<1$ $y<1$ $y>x$ x and y both fractions.

(b) $x>1$ $y>1$ $x>y$ x and y both more than 1.

(c) $x = 1$ $y = 1$ $x = y$. Subtangent is 1.5.

THE UNIT PARALLELOGRAM AND REPRESENTATION OF POWERS AND ROOTS.

Suppose a long directed envelope. The left edge is x. The lower left corner is 0, at x distance draw x at right angles to both edges, x^2 is made. At vertical from 0 distant 1 from it draw the line making two parallelograms with verticals 1 and $x-1$, respectively. The upper edge we will know as the x level, the running line as the level of 1. Draw the principal diagonal of x^2 from 0. It is also a diagonal of 1^2 or in terms of x, x^0.

Through the level of 1 diagonals are to be successively drawn after the following manner. All run from zero to the x level. Verticals thence dropped to the base ascertain by the cross points on the level of 1, how the diagonals are to be drawn. The first diagonal is through the cross point down from x. At the x level it ascertains the corner of $x^3 = x^2\,x$. The vertical from x^3 at the base ascertains the line or number x^2. For, by cross parallelograms, $xx = x^2 1$. Thus as far as the drawing can be carried we have on the x level ${}^1/x$, 1, x, x^2 x^3 x^4 &c. And below on the 0 level $1/x^2$ $1/x$ 1 x x^2 x^3 corresponding. On the principal diagonal (by further development) the squares x^2 x^0 x^{-2} x^{-4} may be shown, and the levels ${}^1/x$, ${}^1/x^2$, ${}^1/x^3$, &c. On somewhat similar principles, $1>x$, x^4 x^3 x^2 are shown for fractions, $x = {}^{7/9}$ for example. We leave this as a problem.

AN ANALYSIS OF AN EXPERIMENT IN TEACHING FIRST-YEAR MATHEMATICS.[1]

By Ina E. Holroyd.

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For several years the writer has been interested in the work of first-year mathematics—the problem of what to teach and how to teach it. With this problem in mind she has taught, during the past two years, seven classes in college entrance algebra. It is to set forth the salient points in the presentation of the subject, and in the results obtained in what she believes to have been a very satisfactory experiment, that this paper is written.

The text used as a basis for this work was *Fundamentals of High-School Mathematics*, by Rugg and Clark, a text of the "unified" type, though conservative, but constructed upon the conviction that ninth grade mathematics needs a complete reconstruction rather than a reorganization. The outstanding features of the course are: (1) Selection of subject matter on the criteria of "Social Worth" and "Thinking" outcomes; (2) The unique arrangement of the material. The first semester algebra develops symbolism and the equation. A very rational presentation of signed numbers and a new method of teaching factoring constitute the chief features of the second semester algebra. The text was supplemented by material chosen from one of the conventional texts in the second semester.

The primary aim in teaching mathematics is not so much to impart facts as to develop a mode of thought; namely, a problem-solving or scientific attitude of mind, the ability to analyze and see relationships, and to determine them. This requires clear ideas and sound associational processes and cannot be developed without much practice in meeting real problem-situations. For this reason the central idea throughout the course was that of problem-solving. The underlying meanings of the course in algebra may be classified under two headings: namely, the narrower associations of ideas that have to do with developing the various phases of the subject, and the broader basic concepts of the equation and functionality. The mental processes in these two classes are the same; namely, the association of ideas in past experiences with the new ideas presented by the new technical vocabulary of the subject.

Arithmetic deals with quantitative ideas expressed by words

[1]An abstract of a discussion given before the Kansas Association of Mathematics Teachers.

or by numbers. Numbers are symbols representing a high degree of abstraction. Algebra, on the other hand, deals with the devices of manipulating these quantitative ideas through the use of letter symbols for numbers. This is a much higher degree of abstraction. We must agree, however, that the mastery of this symbolism plays a very important part in the mastery of the subject.

The first problem involved in learning algebra is, then, the development of its symbolism, how and why to represent numbers by use of symbols. A student is likely to get on very much better in his use of symbols and in his appreciation of their meaning if the economy of time and of mental energy obtained by their use is stressed. Hence the meaning of symbolism is best fixed by associating with symbols the idea of abbreviation —of "representing" or "standing for."

A clear grasp of the significance of the use of letters to represent numbers can come only by the most gradual transition from the use of words to the use of letters as symbols for numbers. Letters are highly abstract in that they represent no particular content, and the pupil must bridge this gap between his past experiences and the new situation expressed by this abstract symbolism. If he is carried forward too rapidly in the course, or if too many things are attempted, there is introduced an element of guess work and confusion which explains many of the failures in this subject.

Association is the basis of habit formation, and the whole process of learning is a process of establishing a system of habits such that a correct response comes with a given situation. The law of habit formation is repetition, hence the pupil needs not only gradual transition from work symbols to letter symbols, but also much repetition. Therefore, the inclusion, as in one traditional text, of $3x+5x$ = how many x? as, the fifth problem proposed for solution is unpsychological and unpedigogical. The pupil can make neither the association with previous ideas as 3 bu.+5 bu. = how many bu., nor can be make the transition without much repetition of such material with the intervening step $3b+5b$ = how many b? Initial letters help to bridge the gap, since the degree of abstraction seems less than with the use of x or y.

As a means of clarifying algebraic symbolism, perhaps the simplest is the construction and evaluation of simple formulas from arithmetic and geometry such as those for percentage

and its applications, for perimeters of rectangles, for areas of rectangles and triangles, for volumes, etc. Problems from denominate numbers suggest a never ending source of supply. How many eggs are 6 dozen eggs and 2 dozen eggs? Using d for 12, how many eggs in $2d+3d$ eggs? Change $7y$ (yards) $+6f$ (feet) to smaller units, that is, to inches. If $y = 3f$, how many f in $4y+6y-3y$?

Translation is a vital step in the comprehension of algebraic symbolism and of mathematics as a language. Important phases of translation are recognition of equality between two quantities and ability to express this equality by means of symbols. As a second step in clarifying the idea of symbolism much translation from algebraic statements into verbal language as well as the reverse is invaluable. Illustrative examples of each.

1. $n+4=13$ is the same as the word statement, "The sum of a certain number and 4 is 13": $4y=26$ should be translated "The product of a certain number and 4 is 26" or "Four times a certain number equals 26."

II.

(a) The "word" method of stating the example.	(a) There is a certain number such that if you add 5 to it the result will be 18. What is the number?
(b) An abbreviated way to write it.	(b) What number plus 5 equals 18?
(c) A more abbreviated way to write it.	(c) No.$+5=18$.
(d) The best way to write it.	(d) $n+5=18$.

The functional relation is fundamental in mathematics and is the central organizing principle of algebra. Its method is essentially that of the equation. Although this is conceded by mathematicians, the traditional text does not make it so. In the supplementary text referred to, for example, only sixteen per cent of the total problem content of the book is verbal and equational work, while 84 per cent is consumed in formal exercises for the acquiring of manipulatory skill, whereas substantially the reverse is true of the text experimented with. It might be noted here that psychological analyses show, and experience bears out the statement, "that skill in the manipulation of an isolated operation does not function effectively when the operation is associated with other operations in new situations." Application is an explicit phase and practice must be given in the application of the operation to prevent its degener-

ating into mere rote memory. This neglect to make application of a skill learned, again explains many failures in algebra.

In developing the concept of the equation as representing a balance of values, specific comparison was made with the weighing scale. The meaning of balance is thus fixed and the idea is developed that whatever is done to one member of the equation must be done to the other, to preserve the balance.

The fundamental notion concerning two quantities which "change together" and with it the idea of the "constant" and "variable" is developed in the text used by three methods—the tabular, the graphic, and the equational. The association necessary for connecting the values in the three methods so as to fix the idea that the table, the graph, and the equation set forth the same truths should be clearly brought about. Meanings are fixed only through many responses to situations in which they occur, hence the value of tabulating, graphing, and symbolizing by equations the relationships which exist between pairs of variables to give the pupil a grasp of the meaning of functionality. The use of similar triangles and of trigonometric ratios (cos and tan) in problems of finding unknown distances to give meaning to ratio and proportion sets up an association with real experiences and takes the topic out of the realm of the abstract into that of the concrete—the concrete including at any stage all the abstractions previously made and assimilated.

The facts in connection with understanding the step-by-step process by which the child-mind learns would, it seems, convince the thoughtful teacher that first semester algebra is not the psychological place to introduce the subject of signed numbers and their use. The pupil has quite enough to do to conquer the high degree of abstraction involved in literal symbolism and the basic idea of the equation. He cannot take ideas so rapidly and assimilate them; and, moreover, he does not need them. He has at his disposal an amount of intuitive knowledge which will enable him to solve equations of the simpler type as he gradually formulates his axioms. Signed numbers were therefore taken up as the opening topic in second semester algebra. To develop the broad concept of "Oppositeness" with the use of positive and negative numbers, specific associations must be made: associating the idea with above and below and after on the time scale, etc.; the central aim being to fix the meaning of sense in numbers—that positive and negative express oppositeness. It should be clear that the same point may lie in the

positive or the negative direction from the origin from which the distances are measured; i. e, the zero point.

A rational presentation of the principles governing the use of signed numbers in the four fundamental operations requires specific association of ideas.

1. Associating with readings of the thermometer at different times to introduce addition; for example:

The top of the mercury column of a thermometer stands at zero degrees (0). During the next hour it rises 3°, and the next 4°. What is the temperature at the end of the second hour?

If it starts at 0°, rises 3°, then falls 4°, what is the reading?

2. Associating with saving or losing a given amount of money for a given time, introducing multiplication;

If you save \$5.00 a month (+\$5), how much better off will you be six months from now (+6)? Evidently you will be \$30 better off (+\$30). Thus +5 times +6 = +30.

If you are wasting \$5.00 a month (−\$5.00), how much better off will you be in 6 months from now (+6)? Evidently you will be \$30 worse off (−\$30). Thus −5 times +6 = −30.

3. Associating with the making of change or with readings on the thermometer at different places, introducing subtraction:

If a customer gives the clerk 50 cents in payment for a 27 cent purchase, the clerk begins at 27 cents and counts out enough money to make 50 cents. i. e., the clerk begins at the subtrahend, 27 cents, and counts to the minuend, 50 cents.

On a certain day the mercury stands at −4° in Chicago and at +13° in St. Louis. How much warmer is it in St. Louis, or what is the difference between +13° and −4°? Naturally, we do the same thing the clerk does, begin at the subtrahend and count to the minuend; i. e., we count from −4° to +13°. giving us +17°. The difference is called positive, because we counted upward. If we counted downward, the difference would be called negative. The same reasoning may then be applied to the abstract number scale finally dropping even this. Division is taught as the opposite of multiplication:

$$\frac{+8}{-2} = -4,$$

because $(-2)\ (-4) = +8$, etc.

Perhaps one of the greatest stumbling blocks in beginning algebra is the subject of factoring. It has been estimated that 39 per cent of all recurring errors indicate positive inability in

particular types of factoring. The traditional presentation of the "57 varieties" or "cases" of "Special Products and Factoring" results in much loss of valuable time, largely because they are so arranged that the learning of one actually inhibits the learning of the others. The reason for this is that the pupils have acquired skill in the several "cases" which they cannot generalize. An analysis of the learning process shows that if such a generalization could be made in the initial presentation of the topic, much of the difficulty would be removed. As a matter of fact the general quadratic trinomial, ax^2+bx+c, will handle all of the "cases" except that of "common factor," which can be taught in connection with multiplication and division, and a^3+b^3 which may be omitted until third semester algebra.

Visual imagry is the predominating feature in the handling of this subject, hence to present many times to the pupil the product of two general binominals $(2x+3)(3x+4)=?$ thus stressing the importance of the middle term greatly facilitates his grasp of the meaning of the process of factoring ax^2+bx+c. Expansion of such products may be motivated by using it as a tool to find areas of rectangles. In all work the pupil should be required to translate his operations into words. Words are the instruments of abstraction and they aid the pupil to analyze the situation. Experience will soon lead him to make classifications for himself; for example, when the binomials are alike he has a perfect square, the bx term being twice the product of the given terms—a fact of importance to him when teaching him to solve the quadratic equation by "completing the square" —or, again, if the binomials are alike except for sign, the bx term is zero. He will observe the converse statements for himself. As soon as the pupil's response to the situation $(\quad)(\quad)=?$ becomes automatic he should reverse the operation and factor, and again appeal to visual imagry as suggested by such a form as $15x^2-14x-8=(\quad)(\quad)$. Such a method is well adapted to bring about "logical thinking," and moreover has the added advantage of saving about three-fourths of the time usually allotted to this subject.

It might be remarked here that analysis of the learning processes shows that the most economical place to teach an opera-

tion is in connection with its application. So here, after the five or six recitations necessary for the presentation, factoring is best taught in the solution of equations and in fractions.

Such a procedure as the foregoing does not build any habits which inhibit any other learning and gives the pupil a power of generalization which develops a grasp of the larger aspects of his subject—a thing to be cultivated in every situation with which he is confronted.

Of the seven classes upon which this text was tried out, four were first semester algebra, with a total enrollment of 72 students and three were second semester algebra with an enrollment of 46. The students were older than ordinary ninth grade students, the average being about twenty years, and most of them had not had preparation beyond the fifth grade. About one-third were ex-soldiers receiving federal aid for vocational training. Of the entire 118 students, only five have thus far entered a curriculum requiring mathematics beyond the two units required for entrance, and it is not likely that more than a half dozen more will do so. Of the five mentioned, three took third semester algebra and entered the three-hour college algebra courses given for students offering one and one-half years of algebra for entrance, while two passed from the second semester algebra into the five-hour college algebra course given for students offering only one year of algebra for entrance. All passed their college algebra, three with grades above average. It is worthy of note that of these three two were in the five-hour course.

It is the belief of the writer that the very gradual exposition of the text, i. e., keeping "the content of the course just a step in advance of the developing content of the student's mind," in the first semester algebra, gave the classes the momentum which enabled them to begin second semester algebra with the operations upon signed numbers and yet complete the usual work of first year algebra in the allotted time. This she attributes largely to the accumulation of reasoning ability. It was her experience also that the procedure herein set forth not only saved time but that the better methods of presentation gave the students a more complete grasp and insight into the fundamental notions and devices of the subject than has been the result to those receiving the traditional presentation. The proportion of failures in these classes was from 5 per cent to 10 per cent lower than in classes given instruction in conventional texts.

The special aim in first year algebra should be "to give the pupil the ability to use the tools of quantitative thinking—namely, the equation, the formula, and the graph." The experience with these students in college algebra would certainly seem to show that emphasis on problem-solving tends to develop greater skill in the manipulation of these tools than does emphasis on the side of manipulation alone.

Furthermore, the social worth of the material presented was far greater for the 100 or more students who did not take further mathematics, than that of the usual tradition text, and this belief was confirmed by the more mature members of the classes. They felt they had "something practical," "something we can use."

LEARNING FRACTIONS.

By Myrtie Collier.

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While the National Committee on Mathematical Requirements is reconstructing high school and beginning college mathematics, it is the duty of the common schools to reorganize and improve the greatest of all branches of mathematics, arithmetic. It is the purpose of this article to discuss some reforms needed in the work in fractions.

What to Learn.

This reform must begin with the elimination of nonessentials in subject matter. It is the paramount duty of the school to find out what is worth the child's knowing. To do this the school must study society to determine what subject matter is being used, and then determine what addition or substitution, if any, would lead to greater efficiency.

A committee on the Minimum Essentials in Arithmetic, composed of representatives from the schools of ten of the leading cities in southern California and from the Southern Branch of the University of California, sent out three questionnaires last year in an effort to discover the number being used in the social life of the community. Question eight of the first questionnaire was: How many of the following denominations of fractions do you personally have occasion to use: halves, thirds, fourths, fifths, sixths, sevenths, eighths, ninths, tenths, twelfths, sixteenths? From the 799 replies received from persons in the various walks of life, it appeared that

585 used halves.
494 used thirds.
571 used fourths.
331 used fifths.
293 used sixths.
229 used sevenths.
324 used eighths.
180 used ninths.
302 used tenths.
221 used twelfths.
204 used sixteenths.

Taking the median of the replies to the question and using all numbers greater than this median it is shown that the minimum essentials are the fractions—halves, thirds, fourths, fifths, eighths, and tenths.

The second questionnaire was sent out to supplement the first one and the study made by Dr. Coffman and Dr. Jessup in 1913. Each individual kept the questionnaire through a period of ten days, and made note of the number of operations which he used each day. There were 314 persons replying to this questionnaire. Taking the median of the per cent of usage of the total replies, 9.8 per cent and regarding all numbers above this median as constituting the minimum essentials, it is shown that the four processes in fractions are found to be essential.

	Frequency of Use by 314 persons during 10 consecutive Days.	Per Cent of Usage of total Replies.
Addition of Fractions	894	28.4
Multiplications of Fractions	716	22.4
Subtraction of Fractions	637	20.1
Divisions of Fractions	545	18.0

Note: Many persons think that they are dividing by a fraction when they are taking the fractional part of a number. The committee, therefore, did not recommend the division of fractions as a minimum essential.

All employers responding to a third questionnaire reported their employees deficient in the use of simple fractions.

From a summary of the three questionnaires and such other studies as have been made, the committee recommended the following as the minimum essentials in fraction work: addition, subtraction, and multiplication of the following fractions: halves, thirds, fourths, fifths, eighths and tenths.

How to Learn Fractions.

If we agree with Professor John Dewey "That there is no such thing as genuine knowledge and fruitful understanding

except as the offspring of doing," our method of procedure in presenting fractions is indicated.

Numbering is answering the question how many or how much. Fractioning is numbering in that it gives a complete expression through its notation of the process of measurement. "$3-4 is defined in terms of the primary unit (one dollar); the actual unit of measure is derived from the primary by dividing it into four equal parts and taking one of the parts (one-fourth dollar); the numerator 3 shows how many of these units make up the given quantity, and expresses the ratio of this quantity ($3-4) to the derived unit ($1-4). In the expression $3-4, note that the number is the numerator 3; fourths designate the repeated unit; there are three *fourths*. This is true whether the primary unit is a single dollar or a number of dollars." (Howell.)

The child's beginning work in fractioning, however, is dividing a *single thing* into one or more equal parts. The ratio idea comes later. In learning fractions, therefore, the child must be allowed to perform such activities as necessitate the measuring of things with a unit of measure smaller than unity so that problems are presented which can be solved only by the use of fractions. For example, in playing store, the child may have occasion to add 1-2 lb. and 3-4 lb. and may find from reading the scales that it is 1 1-4 lb. In like manner he discovers that 1-2 yd. and 3-4 yd. is 1 1-4 yd. Through his handwork and his work in the garden he discovers that 1-2 in. and 3-4 in. is 1 1-4 in. Following such experiences the abstract operation is given, and the child learns that the sum of 1-2 and 3-4 is always 1 1-4, a fact which is his to use as truly as is the fact that 2 plus 3 equals 5. In other words, it is through "doing," in school and out of school, that a need for fractions is met. When once this need has been created, the principle involved in the mechanics of fractions should be developed through handling of the concrete objects as in paper tearing, guided by skillful questioning on the part of the teacher.

Learning to Add Fractions.

In the addition of fractions, only those fractions should be added whose combinations are justified by our standard measures. Why should the child add a third and a fifth when there is no scale whereby one can measure a third and a fifth of like material? Such approximate combinations belong in decimals. The following is a good grouping:

Halves and halves,
Halves, fourths, eighths,
Halves, thirds,
Halves, thirds, sixths,
Halves, thirds, sixths, twelfths,
Halves, thirds, fourths, twelfths,
Fifths and tenths.

Or:

1/2	1/2	3/4	3/4	1/4	3/4	3/4
1/2	1/4	1/4	1/2	1/8	1/8	3/8
1	3/4	1	1 1/4	3/8	7/8	1 1/8

1/2	3/8	1/2	1/2	1/3	1/2	5/6
1/8	1/2	1/3	2/3	2/3	1/6	1/2
5/8	7/8	5/6	1 1/6	1	2/3	1 1/3

1/3	2/3	5/6	5/6	1/3	2/3	3/4
1/6	1/6	1/3	2/3	1/4	1/4	1/8
1/2	5/6	1 1/6	1 1/2	7/12	11/12	7/8

3/4	3/4	1/5	2/5	7/10
1/3	2/3	1/10	3/10	3/5
1 1/12	1 5/12	3/10	7/10	1 3/10

Through such grouping the pupil is able to add fractions in column addition by the *unit* method, thus:

7 1/2	The child thinks:
3 3/4	(1) 1/2 and 3/4 are 1 1/4.
2 3/4	
5 1/8	
19 1/8	(2) 1 1/4 and 3/4 are 2.
	(3) Writes 1/8 in fractions' column.
	(4) Adds 2 to units' column.

or

(1) 1/8 and 3/4 are 7/8.
(2) 7/8 and 3/4 or 6/8 are 1 5/8.
(3) 1 5/8 and 1/2 or 4/8 are 2 1/8.
(4) Writes 1/8 in fractions' column.
(5) Adds 2 to units' column.

or

(1) 3/4 and 3/4 are 1 1/2.
(2) 1 1/2 and 1/2 are 2.
(3) Writes 1/8 in fractions' column.
(4) Adds 2 to units' column.

Reduction of fractions should be taught along with addition of fractions, since it is in adding of unlike fractions that the process of reduction is needed. When the child is confronted with the problem of changing the denomination of fractions, a few guiding questions from the teacher should help the child to discover the principle of reduction. Suppose the child wishes to change 2-3 to sixths. His question is "2-3 equals how many sixths?" Through measuring he may discover that 2-3 equals 4-6. Then ask "What did you do to the three to get the six?"

"Multiplied by 2." "What did you do to the 2 in the numerator to get the four?" "Multiplied by 2." The pupil should show the work on the board.

$$\frac{2\times 2}{3\times 2}=4\text{-}6$$

The pupil should change 3-4 to eighths in the same way.

$$\frac{3\times 2}{4\times 2}=6\text{-}8.$$

The child may measure to check the result. After a few such exercises ask the child to multiply mentally, that is, without writing down the number by which he is multiplying, as

$$2/5=6/10.$$

Reduction to lower terms is learned in a similar manner, only here both terms of the fraction are divided by the same number: as

$$\frac{2}{4}\div\frac{2}{2}=\frac{1}{2},\quad \frac{9}{12}\div\frac{3}{3}=\frac{3}{4},\quad \frac{6}{10}\div\frac{2}{2}=\frac{3}{5}.$$

There is no place in arithmetic for the formal work in finding the least common denominator.

After the class has found a need for the combinations in fractions, the following game offers a good drill both in the reduction and the addition of fractions. Give each child in the class an envelope containing a unit strip of paper, and many stripes that are fractional units in length, 1-2, 1-4, 2-4, 3-8, 3-4, 1-8, 7-8, etc. Let the child match the fractions in all possible ways to make the unit, thus:

When the combinations have been made, let each child place on the board the picture of the grouping on his desk, referring to the original if necessary. Each child should say over his grouping. Following this should be a rapid drill given by the teacher in which the digits only are used, thus omitting the diagram. Lastly, should come column addition by the method of grouping as illustrated above.

Learning to Subtract Fractions.

Since there are only two numbers involved in the subtraction of fractions, all necessary reduction can be done mentally.

3-4 If the child does not know the combination, he thinks
−1-2 1-2=2-4. 2-4 from 3-4 leaves 1-4.
— —
1-4

The new work in the subtraction of fractions is in subtracting mixed numbers where the larger fraction is to be taken from the smaller. Example: $7\frac{1}{2}$
$-2\frac{3}{4}$

Through questioning the teacher leads the pupil to discover that the same thing must be done here as in whole number. The child then thinks: (1) $1/2-2/4$.
(2) Take 1 from 7.
(3) $1=4/4$.
(4) $2/4$ plus $4/4=6/4$.
(5) $3/4$ from $6/4$ leaves $3/4$.
(6) 2 from 6 leaves 4.

(This should all be done without paper and pencil.)

Through the teaching of Miss Matilda Behrens, who was at the time a student teacher under the supervision of the writer, a class developed independently the method of taking the fraction in the subtrahend from the unit taken from the units column in the minuend, and adding the remainder to the fraction in the minuend, thus:

6 1/2 First step. Take 1 from 6.
−2 2/3 Second step. $1-2/3=1/3$.
—— Third step. $1/2+1/3=5/6$.
3 5/6 Fourth step. $5-2=3$.

In the initial work in subtraction of mixed numbers, in taking a mixed number from a whole number the child quickly forms the habit of taking the fraction from the unit taken from the units column, thus:

7 First step. Take 1 from 7.
−2 1/4 Second step. $1-1/4=3/4$.
——— Third step. $6-2=4$.
4 3/4

Through Miss Behrens, who is now a principal in Waterloo, Iowa, the schools of that city have tried out the above method of subtraction of fractions, and the method of grouping in the

addition of fractions, with the most gratifying results.

Superintendent Charles W. Kline writes of this work in Waterloo: "I have observed the work of pupils in the fourth and fifth grades in addition and subtraction of fractions where they followed the usual method of reducing to a common denominator and where they used the objective method. Pupils work much more rapidly and secure better results by the new method. They seem to understand the whole subject of fractions much better than those taught by the old method. On a test given on the same problems in fractions the results were as follows:

New Method:

4 A No. of minutes 10 Median No. problems right 27.

5 B No. of minutes 12 Median No. problems right 28.

Old Method:

4 A No. of minutes 30 Median No. problems right 5.

5 B No. of minutes 10 Median No. problems right 14.

The results of this test would seem to indicate that much better results can be secured in the teaching of fractions by the objective method than by the usual method of reducing to a common denominator."

ABSOLUTE TEMPERATURE.

BY KIRSTINE MEYER, NEE BJERRUM[1]*

Translated by Willard J. Fisher, 28 Baker St., Worcester, Mass.

To fix the conception of temperature as measure of thermal condition, we must make a series of assumptions and base ourselves upon a series of experiences. First, we must define what is meant by

1. Two bodies have equal temperatures;
2. One body has a higher temperature than another.

Then we must proceed from the following experiences:

A. If of two bodies each has the same temperature as one and the same third body, then they have mutually the same temperature.

B. If we choose a particular body A, of which certain properties change under the influence of heat, and bring this body A in contact with a series of other bodies which exert an influence on these properties, then these bodies can be divided

[1]*The following pages were published under the title, "From what hypotheses must we start, in order to be able to define the concept temperature," in Zeitschrift für physikalischen und chemischen Unterricht, May, 1910.

into two groups; those in one group have higher temperatures than A, the others lower. This grouping remains unchanged, if the body A be replaced by another which has a temperature equal to its temperature.

The body A is called a thermometer, i.e., a contrivance with which one recognizes temperature differences.

Further there come into account

3. The body used as the thermometer;

4. The property of this body, whose change measures the thermal condition.

5. The notation used in the measurement, i.e., the temperature scale.

From the preceding, it appears how hard it was to get clearness on these points. Aristotle could not overcome the difficulties appearing in 1 and 2; Boyle first essentially attained this, when he used the thermometer with inclosed liquid.

In the course of the eighteenth century, facts were learned by which all these points could be cleared up. Hereupon there arose the new problem, to find a scale whose reading measures the "quantity" or "power" of applied heat, independent of the thermometer used.

In the middle nineteenth century the so-called absolute temperature scale was proposed, i. e., a scale whose indications are independent of the thermometer used, and also independent of the property, whose change is used in the measurement. We wish here to show what further points are to be considered with the introduction of this scale.

The newly discovered facts and the assumptions founded on them are:

C. Heat is a form of energy; if heat is produced by work, there is a constant ratio between the heat produced and the mechanical work used.

By this we can define unit heat independently of the temperature scale. If, for example, we imagine in Joule's experiments on the production of heat from work an ice calorimeter substituted for the ordinary calorimeter, then 3 *cg.* ice are melted for every meterkilogram of work that disappears. As a unit for measuring quantity of heat we could then introduce the amount capable of melting 3 *cg.* ice at the freezing point under the pressure of 1 atmosphere.

D. Principle of S. Carnot. If a reversible cyclic process goes on between two bodies with different but constant tempera-

tures, then the ratio between the heat quantities Q_1 and Q_2 given off by the first body and taken up by the second depends only on their temperatures and is entirely independent of the body in which the cyclic process goes on, and also of its properties, which perhaps change during the process. According to the proposition of W. Thomson (later Lord Kelvin), we measure the temperature of the changing body during the intake and outgo of heat by the numbers θ_1 and θ_2 satisfying the equation $Q_1/Q_2 = \theta_1/\theta_2$.

If we fix the number measuring one of the two temperatures, then the other is determined independently of the body which goes through the cyclic process. If we consider this body as a thermometer, we get in absolute measure the temperature of one of the two heat sources, as during the process these were in temperature equilibrium with the thermometer.

The meaning of the zero point of this absolute scale we find thus:

$Q_1/Q_2 = \theta_1/\theta_2$, or $Q_1-Q_2/Q_1 = \theta_1-\theta_2/\theta_1$.

If we assume that θ_1 is the temperature of that heat source from which the work (or heat quantity) Q_1 is received, while θ_2 is the temperature of that which received the work Q_2, then we see that the useful effect (efficiency)

$$Q_1-Q_2/Q_1 = \theta_1-\theta_2/\theta_1$$

approaches 1 as θ_2 approaches zero. Consequently the absolute zero is the temperature of the colder body approached as the efficiency approaches 1.

It is now to be studied, how the temperature number can be expressed on the scale of any thermometer whatever. For any reversible cyclic process[2] the equation holds, $dQ/\theta = 0$; i. e., for any arbitrary portion of the process the value of this integral depends only on the initial and final conditions, or dQ/θ is a perfect differential.[3*] If we assume for the two

[2*]For elementary discussions of reversible and other cycles, see the textbooks of physics or heat, as Duff's, pp. 281-295, Watson's, pp. 299-335, Reed and Guthe, pp. 216-229, Anderson, pp. 323-326, Carhart, 409-448, Spinney, 230-244

[3*]For discussions of the meaning and properties of perfect differentials, see textbooks on calculus, as

Murray, Differential Equations, pp. 17-22.
Johnson, Differential Equations, pp. 22-29.
Murray, Infinitesimal Calculus, p. 141.

That dQ is not a perfect differential, or that the amount of heat taken in or given out by a substance during a thermal change depends not only on the initial and final states of the substance but also on the way in which the change from initial to final state is made is clear from the following:

Imagine a piston and cylinder of heat-insulating material containing a hot compressed gas; allow the gas to expand and push the piston before it (which happens when we pull the trigger of an airgun); the gas will cool down as it overcomes the pressure of the external atmosphere, until its own pressure is equal to atmospheric. But, as the walls are insulating, no heat has entered or escaped. The pressure and temperature, however, have fallen, and the volume increased to perfectly definite and fixed values. Line AB represents the change.

variables which determine the state of the body, first the temperature t, measured on any thermometer, second, any y whatever, then $dQ = P\,dt + R\,dy$.[4*]

$$dQ/\theta = (P/\theta)dt + (R/\theta)dy.$$

As dQ/θ is a perfect differential,

$$[\partial(P/\theta)]/\partial y = [\partial(R/\theta)]/\partial t$$

then, since θ is a function of t only[5*]

$[(1/\theta)(\partial P/\partial y)] = [(1/\theta)(\partial R/\partial t)] - [(R/\theta^2)(d\theta/dt)]$, or
$[(1/\theta)(d\theta/dt)] = 1/R[(\partial R/\partial t) - (\partial P/\partial y)]$.

As the left hand side is a function of t only, so is the right hand, hence

$$\theta = \theta_0 E^{\int_{t_0}^{t} [1/R(\partial R/\partial t) - (\partial P/\partial y)]dt} \qquad (1)$$

So we have the absolute temperature expressed in terms of the temperature t, measured on the scale of any thermometer.

In particular, we can choose as second independent variable the volume v. Then

$$dQ = Pdt + Rdv.$$

If the pressure to which the body is subjected is p, then the increase of internal energy during the reversible process is $dU = dQ - pdv$, which is a perfect differential[6*], being dependent only on the initial and final states, according to the first law.[7*] But if $dV = Pdt + (R-p)dv$ is a perfect differential, then

$$\partial P/\partial v = [(\partial R/\partial t) - (\partial p/\partial t)], \therefore [(\partial R/\partial t) - (\partial P/\partial v)] = \partial p/\partial t$$

and, by substituting in (1)

Suppose again the same gas with the same initial temperature and pressure in a cylinder and piston of the same dimensions but of a conducting material. If we cool the whole down, not by allowing the gas to expand, but by means of cold water poured on, we can bring the pressure down to atmospheric without any change in volume, without allowing the piston to move. Heat has been taken away in definite amount. Line AC represents the change. Now we can release the piston, and, by adding heat, as by pouring on hot water, we can make the gas expand, all the while at atmospheric pressure, until it has the same volume as at the end of the first case. Line CB. The gas is now of a certain volume, pressure and temperature, reached in the first case with no addition or subtraction of heat, in the second case with first an addition and then a subtraction, which, however, do not balance each other. The heat abstracted by the cold water was more than that added by the warm water. So the quantity of heat used in carrying the gas from the initial condition to the final depends greatly on the way the change is made.

[4*]P and R are coefficients which are known to be in general functions of t and y, but of a form as yet unknown. The equation says that Q depends on t and y. This statement is allowable, since we have tacitly assumed that the substance in the engine—steam, air, or whatever it may be—has an equation of state, so that its condition as to pressure, etc., and the amount of energy change equivalent to any amount of heat introduced or leaving can be completely expressed in terms of the temperature t and one other variaole, which latter may be selected from a wide range of physical qualities.

[5*]The relation between θ and t is purely a numerical one, they being both temperatures, and depends only on the fixed points arbitrarily selected for the two scales, and on the law for the size of a degree, as that the degrees are uniform in size, or some other law.

[6*]Though dQ and pdv are not dependent *solely* on the initial and final states, their difference is.

[7*]The first law is really stated in the equation above, or thus, $dQ = dU + pdv$, or, the heat added to a body is equivalent to the increase of the internal energy of the body plus the external work done by the body during the addition of the heat.

$$\theta = \theta_0 E^{\int_{t_0}^{t} [(1/R)(\partial p/\partial t)]dt} \qquad (2)$$

in which R is the quantity of heat measured in work units, called the heat of expansion along an isotherm;[8*] or, $R = (\partial Q/\partial v)t$ = const., whence it follows from (2) that $(1/R)$ $(\partial p/\partial t)$ is a function of t only.

Now consider one or two examples.

(1) Let the body considered be a saturated vapor; then p is a function of t only,[9*] and (2) can be written

$$(\theta/\theta_0) = E^{\int_{p_0}^{p} (dp/R)}.$$

(2) Let the body be air, obeying Joule's law;[10*] then the heat quantity absorbed during expansion along an isotherm is equal to the external work done, or $pdv = Rdv$, or $p = R$.

Then from (2), $$\theta = \theta_0 E^{\int_{t_0}^{t} [(1/p)(\partial p/\partial t)]dt}$$

To get the relation of the two temperature scales, imagine the integration carried out from a point of the isotherm t_0 to a point on the isotherm t; choosing these two points on the same ordinate, corresponding to equal volumes, and integrating along this ordinate, then $$(\theta/\theta_0) = E^{\int_{p_0}^{p} (dp/p)} = (p/p_0) \qquad (3)$$

in which p and p_0 designate the pressures of the gas at constant volume and at the temperatures considered.

In an air thermometer, in which the inclosed air is kept at constant volume, the temperature is expressed by

$$p = p_0 \propto T.$$

The temperature thus defined agrees with the absolute temperature, if the inclosed gas obeys the law of Joule, of which the law of Mariotte and Gay-Lussac is a special case. This follows from (3), for $p = (p_0/\theta_0)\theta = F(v) \cdot \theta$ since p_0/θ_0 is some function or other of the volume, though not necessarily that demanded by the law of Mariotte and Gay-Lussac.

Finally the question arises, can the absolute scale be prac-

[8*] i.e., the heat required to do work of expansion without change of temperature.
[9*] So that dp/dt, partial derivative, becomes dp/dt, ordinary derivative.
[10*] Joule's law is based on the experiment described in college texts as follows: Duff, p. 235; Watson, p. 305; Reed and Guthe, p. 220; Kimball, p. 273.

tically completely realized? Is there a gas which obeys Joule's law exactly? Direct experiments for answering this question were made, as is well known, by Joule and W. Thomson; of later such experiments nothing is known.[11*] The result was that none of the gases investigated followed the law exactly; for hydrogen the deviations were least. Consequently, in the year 1888 the hydrogen constant volume thermometer was by international agreement made standard for all temperature measurements, and the temperature scale was defined by $\theta/\theta_0 = p/p_0$, wherein the pressure p_0 at the freezing point of water is made 1000mm. mercury. The temperature difference between the freezing point of water and its boiling point under normal pressure was made 100; so that θ_0, the temperature of melting ice, is determined by

$$(p_{100}-p_0)/p_0 = 100/\theta_0; \quad \theta_0 = (1)/(p_{100}-p_0)/100p_0 = 1/\beta$$

in which β is the pressure coefficient at constant volume. According to P. Chappuis' latest investigations[12], for hydrogen = 0.00366256, so that $\theta_0 = 273.033$. If we use as thermometric substances other gases than hydrogen, we get somewhat different values for β and consequently for θ_0. Chappuis gets for

Nitrogen	$\beta = 0.0036617$,	$\theta_0 = 273.097$
Carbon dioxide	$\beta = 0.00367$,	$\theta_0 = 273.48$

The value of θ_0 obtained with one of the real gases varies little from that which would be got with an ideal gas; the same holds for other numbers on the scale. A series of experiments has been made to determine these variations, i. e., the temperature of a body on the absolute scale has been compared with that according to the international standard scale just mentioned. For this purpose (2) can be applied if the quantities under the integral sign are known, i. e., if, for example, p and R are known for the gases as functions of the temperature within a large interval; at present sufficient data for the purpose have not been obtained. Further, such a comparison can be made on the basis of the Joule-Thomson experiment[13*] with gases which expand adiabatically without complete expenditure of work through a porous diaphragm. The increase of the internal energy of such a gas, going without access of heat from the condition p, v, θ to the condition $p+dp$, $v+dv$, $\theta+d\theta$, is equal to the applied external work; i. e.,

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[11*]The papers of Joule and Joule and Thomson are reprinted in Harper's Scientific Memoirs, I. The Free Expansion of Gases; J. S. Ames, ed., 1898.

[12]Trav. et Mém. du Bureau International des Poids et Mesures, T. 13, 1907.

[13*]The Joule-Thomson experiment is described in Duff, p. 238; Anderson, p. 277; Reed and Guthe, p. 225; Watson, p. 305-307.

$$-d(pv) = -(p(dv)+(v)dp).$$

The same change of internal energy could be brought about by a reversible process; in this the change of internal energy is

$$dU = dQ-(p)dv,$$

in which $dQ = C_p(d\theta)+(h)dp$, $(h)dp$ meaning the heat quantity necessary for an isothermal increase of pressure dp, and C_p the specific heat at constant pressure.

Consequently $-v(dp)-p(dv) = C_p(d\theta)+h(dp)-(p)dv.$

In this $\quad h = -\theta(\partial v/\partial \theta)_p$

and we have $\quad d\theta = (\theta(\partial v/\partial \theta)-v)/(C_p)dp \qquad (4)$

Introducing now the temperature measured on any thermometer as new independent variable, and denoting $d\theta$ and dp in (4) by

$\triangle\theta$ and $\triangle_p$, $\partial v/\partial\theta = \partial v/\partial t \cdot dt/d\theta$

$$C_p = \partial q/\partial\theta = (\partial q/\partial t)(dt/d\theta) = C'_p(dt/d\theta)$$

$$\triangle\theta = (d\theta/dt)\triangle t$$

Substituting in (4), $(\theta/\theta_0) = E^{\int_{t_0}^{t}[(\partial v/\partial t)_p dt]/[v+C'_p(\triangle t/\triangle p)]}$

in which the quantities under the integral sign can be determined by the $\triangle t/\triangle p$ of Joule and Thomson. Here again the determinations, particularly of $\triangle t/\triangle p$, are too few, and also too uncertain. From their experiments Joule and Thomson thought they could deduce $\triangle\theta = (\alpha/\theta_2)\triangle p$ in which α is a constant.

Introducing this expression for $\triangle\theta$ into (4), we get an equation of state for the gas under experiment, from which we can calculate θ and compare this with the temperature got with the normal thermometer. But the equation $\triangle\theta = (\alpha/\theta_2)\triangle p$ has no general validity; it is not grounded theoretically, but set up from the results of experiments over only a small range of temperature.

In the comparison of the two scales we go on in general as just shown; we try to find an equation of state for the real gases containing pressure, volume and absolute temperature; with its help we then find in the given case the absolute temperature expressed in terms of the known values of pressure and volume. This value we compare with the temperature of the gas, got by measurement with the normal thermometer, and so find the discrepancy of the two scales at the point in question. In this way Rose-Innes[14] and D. Berthelot[15] in recent years have tried

[14]Phil. Mag., (6) 2, p. 130, 1903.
[15]Trav. et Mem., T. 13, 1907.

to solve the problem. Rose-Innes has on the whole followed the method sketched in the example above. The equation of state is in general got by a combination of theoretical considerations and empirical laws. Berthelot, for example, starts out from the equation of Van der Waals, derived theoretically. But since it agrees badly with determined values, certain alterations are made in it. Considering the range of their validity he extrapolates rather far.

In these various ways the final conclusion has been reached that there is a close agreement between the two scales, at least between zero and 100°.[16]

At higher temperatures we may expect a better agreement, inasmuch as the isotherms of all gases with rising temperatures approach more nearly equilateral hyperbolas; now, however, a new difficulty is encountered, that of finding a suitable receptacle for the thermometric substance. In fact, it is found that at high temperatures hydrogen reduces glass, porcelain and even quartz; as it further diffuses through a wall of platinum, it cannot be used as thermometric substance in the measurement of high temperatures. Also, at very high temperatures, there is possible a dissociation of the hydrogen molecule into two atoms. Consequently it has been proposed to use nitrogen as the thermometric substance for the normal scale at temperatures above 100°. Experiments on this basis were carried out by P. Chappuis.[17] A comparison between a constant volume nitrogen and a similar hydrogen thermometer showed that the indications of the former varied from the normal scale between 0° and 40°, i. e., about 0°.01, and then grew smaller. The quantity changed, diminishing up to 80°, then it was constant or increased slightly, but only within the limits of observational error. At 100° nitrogen behaves like hydrogen at ordinary temperatures, for its compressibility is smaller than according to the law of Boyle and Mariotte. Hence Chappuis concludes, that from 80° upward nitrogen can be used instead of hydrogen as thermometric substance. To reduce the readings of the nitrogen thermometer to the normal scale, Chappuis proceeds as follows:

$$\alpha = (1/P)(dP/dt) = 0.0036738.$$

Were nitrogen a perfect gas, this would be constant to 0°

[16]According to Berthelot's calculations, the discrepancy in this interval between the thermodynamic and normal temperature scales should amount at most to 0°.00055.

[17]Phil. Mag., (5), 50, p. 433, 1900.

and during cooling from 100^0 to 0^0, the pressure would diminish by 100×0.0036738. Had the nitrogen thermometer been so filled that $P_0 = 1.000$ m., then at 100^0 the observed pressure was $P_{100} = 1.367466$ m., and the corresponding pressure of an ideal gas at 0^0 would be

$$P''_0 = 1.367466 - 0.0036738 \times 100 = 1.000086 \text{ m.}$$

With this the temperatures are computed corresponding to the measured pressure P for temperatures over 100^0, by the formula $\quad P/P'_0 = \theta/\theta_0$.

Helium would be the best adapted thermometric substance; the objections to the use of hydrogen are here of no account;[18] helium approximates to an ideal gas in high degree, and can therefore be used for the measurement of both high and low temperatures. "It is therefore clear, that the normal scale must be that of the helium thermometer."[19] Travers says that for measurement of great temperature intervals constant pressure thermometers would be more practical than those of constant volume, as the long mercury column makes trouble in many ways, partly because the high pressure deforms the receptacle, partly because it is hard to find accurately the temperature of the mercury column.

Low temperatures, producible in the most recent times, are measured with the constant volume helium or hydrogen thermometer. Even in the eighties of the last century Olzewski, in his work on the condensation of gases, measured temperatures as low as -220^0 with the hydrogen thermometer.[20] He compared the indications of gas thermometers filled with hydrogen, nitrogen and oxygen, to -150^0, and found that to this limit they agree; at -150^0 his oxygen thermometer was about 2^0 too low as compared with the hydrogen thermometer; at the critical temperature of nitrogen his nitrogen thermometer was about 1.7^0 too low. On this Olzewski remarks, "The good results, which the gas thermometers give in measurements of low temperatures, are due to the fact, that while on cooling the gases approach their condensation temperatures, yet on account of the simultaneous diminution of pressure they also

[18]According to investigations of the Physikalisch-Technische Reichsanstalt, helium diffuses through quartz even at ordinary temperatures. Zeitschr. f. Instrumentenkunde, 32, p. 122 1912.

[19]Travers, Experimental Study of Gases.

[20]Annalen der Physik, 31, p. 68, 1887.

recede from it." Later he applied the helium thermometer,[2] and gives a comparison of its indications with those of the hydrogen thermometer for the boiling points of liquid oxygen at different pressures.

Such measurements were lately carried out in a more accurate manner by Travers and Jacquerod. Temperatures were measured to -260^0 and Travers proposes to use the helium thermometer for lower temperatures. It seems odd at first that the boiling point of liquid hydrogen can be measured with a hydrogen thermometer, or that of boiling oxygen with an oxygen thermometer; the reason is, that a mass of gas, which is under a pressure of 1000 mm. at 0^0, as for the thermometer of Travers and Jacquerod, at -200^0 shows such a small pressure as to correspond to a vapor so far removed from its saturation point that it still obeys Mariotte's law. In measuring the boiling point of oxygen with a hydrogen, a helium and an oxygen thermometer, we get

H-thermometer	$-182^0.93$
He-thermometer	$-182^0.83$
O-thermometer (less complete form)	$-182^0.4$

The agreement of the values shows that the gases follow nearly the same laws. If helium at this temperature is to be regarded as a perfect gas, so also very nearly are the others.

At very low temperatures there were observed small, but very regularly increasing, discrepancies among measurements of equal temperatures with hydrogen and helium thermometers.

Travers gives the following temperatures, reckoned from -273^0 as zero:

	He thermometer	H thermometer
Boiling oxygen	$90^0.2$	$90^0.10$
Boiling hydrogen	20.41	20 .22
Liquid hydrogen at 100 mm. pressure	15.14	14 .93

Such discrepancies must occur, since helium, even at the lowest of these temperatures, has not reached its critical temperature, while that of hydrogen is about 34^0. So the helium thermometer gives excellent service at the lowest temperatures, though the discrepancies between the two gases are not large.

After a temperature scale has been found, in which the numbers have a rational meaning, there arises another problem, the same, apparently, which occupied Dalton—"Is there a simple

[2] Annalen der Physik, 59, p. 184, 1896.

relation between the internal structure of all substances and their temperature numbers?"

Here we meet the theory of corresponding states, whose meaning is in this connection best summarized thus: If we know for a substance at any given temperature the series of states through which it can pass, then we can name for any other substance a temperature at which it can pass through the same series of states.[22*] An example of such a temperature, at which substances clearly pass through the same series of states, is the critical temperature. Van der Waals, who first set up this theory, asserted, as is well known, that those temperatures correspond which are equal multiples of the critical temperature, and that the corresponding states at those temperatures are those whose pressures and volumes are equal multiples of the critical multiples and volumes.

Some years ago I published a series of researches[23] which showed that Van der Waal's theory of corresponding states did not agree with the available observations, but that a better agreement was reached by computing volume and temperature from zero values characteristic for each substance, and by using units of volume, pressure and temperature also characteristic for each substance.

For the twenty-five substances I plotted a common vapor pressure curve with the abscissa $x = (T_c - T)/K$, and ordinate $y = (P_c - P)/—_c$, in which P_c and T_c are critical pressure and temperature for a given material and K is its temperature constant.

Investigations on the basis of later obtained experimental material have further substantiated[24] these assumptions. For example, with the help of this theory we can calculate in advance the critical temperature of hydrogen.

It would surely be of great importance to our views on the internal structure of matter, if we could find a special "temperature origin" for every substance; recent atomic-kinetic investigations concern themselves with this problem.[25]

[22*] i.e., isothermals have the same form.

[23] Kgl. danske Videnskab. Selskab. Skrifter, VI, 3 Heft; Ztschr. f. phys. Chemie, 32, p. 1, 1900.

[24] Ztschr. f. phys. Chemie, 3, p. 325, 1910, and Temperaturbegrebets Udvikling, p. 164 ff.

[25] W. Nernst, on a general law about the behavior of solid substances at very low temperatures. Phys. Ztschr., 1911, p. 976.

Footnotes marked [1*] have been added by the translator; those with numerals are in the original.

GENERAL SCIENCE FROM THE UNIVERSITY POINT OF VIEW.[1]

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I.

1. *Aims in Teaching Science.*

Before we undertake the direct discussion of this topic we need to find ground for common understanding on certain very fundamental matters. First among these is the determination of the real objectives in the teaching of science. Here is a great field of knowledge, resulting from man's experience and study in the realm of natural forces as they have been revealed to him from age to age. All the essential elements of this knowledge we seek to transfer in our schools to the growing generation in order that its members may carry forward the work that has been begun. We want them to use all the advantage gained, and out of new experiences and continued research to discover new truth to be in turn passed on by them. We mean something like this when we speak of their adjustment to their natural environment. But we undertake much more than the individual's personal adjustment. We seek also to give to him the interest in and the method for further observation and study of the less obvious forces and relationships which exist in the realm of nature.

It appears, then, that our aims differ with the progress made. First of all we are seeking to enable the child or youth to interpret his direct relationship to the life and forces about him. The materials for these are partly natural but largely historical. In transmitting them we generally seek to demonstrate the methods by which they have been attained—methods which must be perfected and carefully organized in order to eliminate the element of waste that has characterized all the earlier experiences of the race.

Our next step is to show how this knowledge and the method of its attainment are to be used in determining conduct as to our environment in nature: in other words, the application of our general knowledge to the normal conduct of our lives. These earlier aspects of teaching are, I take it, the peculiar service to be rendered in the elementary and secondary stages of education.

The third step, that of extending the boundaries of scientific truth through experimentation and research, is the peculiar

[1]Read before the General Section of the C. A S. and M. T., at Soldan High School, St. Louis, Mo., November 25.

service rendered by the universities in the field of education, and as distinguished from the results along similar lines of discovery and invention attained through trained specialists in the fields of commerce and industry. It is from these differing stages in the process of scientific learning that we are supposed to select our materials and methods, as they are to succeed each other through the lower to the higher levels of instruction.

2. *Why General Science and Where?*

Twiss is undoubtedly right in ascribing to Huxley the presentation of the first consistently organized course in general or introductory science, as published by the latter in his monograph on "Physiography" in 1879. Huxley's idea was to introduce young people to the phenomena of nature, in such a way as to enable them not only more fully to organize these experiences, but also to get, at the same time, "some practical experience of scientific method" within the range of the comprehension of youth. We have summed this up in our definition of general science for accrediting at the University of Illinois as teaching the pupils "to interpret their obvious environment, both natural and mechanical, in terms of the fundamental principles of natural science involved."

The general thought of most writers on the subject of general science seems to be akin to the general pedagogical notion that the child naturally proceeds from the general to the particular in his comprehension of environment. For this reason, it is argued, science teaching should begin with the more general, comprehensive view of natural phenomena as a preparation for the specialized courses heretofore common in our high schools. Theoretically, at least, such an order of procedure should begin very early in the child's educational career. It were better, indeed, that even before the school age is attained he should make certain rudimentary beginnings with the process of definitely grouping and relating things. Certain it is that in the elementary grades it is quite possible to accomplish very much of what is meant by a project course in elementary science.

If such a situation were properly provided for through the employment of adequately trained teachers the problem of the high-school curriculum maker would be greatly simplified; and this release of time would extend on to the college and university. Without such provision it still remains for the high school to make the logical beginning. As a consequence, we are told that we inevitably have general science as a high school course.

3. *What Should it Include, and How Should it be Taught?*

In order to answer these questions definitely one would need to know something of the general situation, in a given case, as to the character of the work done in the elementary schools tributary to the secondary schools concerned. It would seem evident enough that, in a school whose pupils have come up through proper teaching of science concepts in the elementary grades, the high school course should undertake work more extended as well as more technically scientific in method than could otherwise be possible.

The situation is not simplified by the wide variation in the character of work done in our elementary schools. It is undoubtedly true that, with proper organization of materials and the adoption of suitable methods, there is a considerable amount of slack that might be used to advantage for the introduction of both natural and social science in the grades above the fourth. Undoubtedly, this confused and unequal condition is a cause for much of the present uncertainty as well as the wide variation in the character of the material proposed for general science courses. Of two features especially the writer of this paper is convinced as matters now stand: (1) That there should be definite contact with the environmental situation as related to the principles to be taught; (2) that much more attention should be given to the historical aspect of science, and especially as found in biographies of the men and women who have been the great pioneers. What more charming and effective means for creating a real interest in scientific lore and in the method of procedure involved than the stories of Helmholtz, Aggasiz, Tyndall, or Madame Curie? Perhaps one of the most regrettable results of our present methods of teaching in the two great fields of science—natural and social—is to be found in the fact that subjects so closely related in actual life are so widely separated in our teaching and study.

Should a general science course be a laboratory course? Most assuredly, if we are agreed as to what the laboratory work should include. In no sense can it be laboratory work such as we expect in chemistry or botany. First of all, nature is the chief laboratory; and most, if not all, of the experimentation should be as a means of interpreting common natural phenomena. In this respect most of the observational work should result in certain demonstrational experiments. As suggested above much of the descriptive work may well be biographical. Text-books should

serve both for preliminary presentation of principles and a resumé of the ground covered by observation and experimentation. The point here is that we are attempting to direct the organization, by the pupil, of his experiences and his readings into logical bodies of knowledge for further use in more advanced study or in the ordinary contacts of life experiences, as the case may be.

II.

Having now located ourselves with reference to the nature and placing of the subject we come to a more pointed consideration of the relation of secondary science to university education. Doubtless we have all heard of remarks by college professors to the effect that they would rather take pupils at the beginning in physics, or biology, or chemistry, than to deal with those who have had an elementary course in either of these subjects in high school. In order fairly to interpret such a remark we need to understand the particular professor's point of view as determined by what *he* is trying to do. In this respect there are at least two ways of considering secondary courses with reference to college work.

1. *Science as a General Factor in One's Education.*

First there is the student, and there are many of the type, who elects science, in one department or another, as a minor, and for the sake of the general information it will give him. If in this case he has entered with science credits from high school it will make little difference with his college work, for he is likely to be differently classified. In a great many cases students entering with such science credits may elect no science at all in the college. In all these cases the matter is one of comparative indifference as far as the college professor is concerned.

2. *Science as Looking Towards its Application in a Professional Course.*

On the other hand, the student who enters upon a professional course where he must apply his knowledge of science is in a very different category. For him the fundamental knowledge of the science required in such a professional training is going to be essential to his success in that field. If he comes to his professional course poorly trained he is worse off than the beginner would be just to the extent of what he must unlearn; and in doing this he is sure to be mentally hampered by the notion that he has had the subject before.

I am sure it is not difficult to see how such a situation would affect the mind of the specialist eager to take his student out to the very frontier of his field; or that other specialist who must build up in his students' preparation a sum of reliable knowledge or ability of manipulation sufficient to enable the early and direct application of this knowledge or skill in the study of professional courses, as in medicine, or agriculture, or engineering.

Here you have a reason for the state of mind of the university specialist with reference to general science as a fitting course to prepare for college. He sees in such a course, with the limited time for science in the high school, a real danger of so limiting the specialized courses as to greatly retard the student's work in college. He also realizes the difficulty in securing teachers for such a general course well enough prepared in the fundamentals of all the branches of science to start the pupils of the high school along right lines of thinking and of practice such as the advocates of the new course propose. As legislation on such matters as entrance credits generally rests with such members of university faculties as are thus interested in advanced professional and research courses, it is easy to see how sentiment opposed to general science would operate.

Briefly, the kind of preparation needed for successful progress in university courses in science is the mastery of the a, b, c's, of the science studied. If this is chemistry the demand is for a thorough knowledge of the combinations of the elements and of chemical equivalence as well as of the means by which simples are to be derived. If it is physics then there is required a dependable working knowledge of the forces operative in the physical world, of their action and reaction, their means of transmission, their measurement and control, and their application to the needs of man. If biology is to be applied then there is required a knowledge of the typical life-forms; of their physiological laws, and of their structural differences as a basis for classification.

If an elementary science course can be organized and successfully taught that will facilitate rather than hinder the thorough attainment of such knowledge and skill as is needed to further the work of research or the application of the sciences to the industries, I am sure it will readily receive the indorsement of all universities. As matters now stand, however, there are many skeptics and very evident cause for their skepticism.

A "TRUE-FALSE" TEST.

By John M. Michener,

High School, Wichita, Kan.

Recently I gave a "true-false" test in physics, one in which the student was given the choice at certain places in a sentence of choosing the right word of two or more given. He indicated his choice by scratching out the wrong words.

When all had finished, papers were exchanged, the correct answers read, and the papers checked and returned. Then they were turned over to me for checking the student's grading.

I used a short method of doing the checking. This is the method: The questions were mimeographed. One sheet, the check sheet, had the correct words cut out of it. To check the grading, this sheet was laid over the paper to be checked. If the questions had been answered correctly, no pencil marks could be seen. One dark hole meant one mistake, and so on. The only error in this method is where the student gives no answer at all, but this is caught by the students, when they grade each other's papers.

One can check and correct the grading of twenty-five papers in five minutes, or one every twelve seconds, by this method.

The same method can be used in grading "completion" tests. Cut out of blank paper, the same size as the mimeographed test paper, holes over the spaces to be filled in. Write the correct words on the blank sheet above the appropriate holes. In grading the paper, then, one simply needs to observe that identical words, or words of practically the same meaning, are under the words on the top paper. One is not bothered by the rest of the sentence nor is his time taken in glancing from the paper to the correct answers or in recalling the correct answers.

By using this method, grading of such papers becomes systematized, greatly shortened in time, and much easier. It is then a routine job, which can be turned over for grading to a person unfamiliar with the subject matter, with the assurance that it will be graded correctly.

This method, of course, can be used in other courses besides physics.

In memory of the achievement of George Rogers Clark in exploring the Northwest Territory, the University of Virginia has unveiled a fine group of seven figures in bronze.—*School Life.*

PROBLEM DEPARTMENT.

Conducted by J. A. Nyberg,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

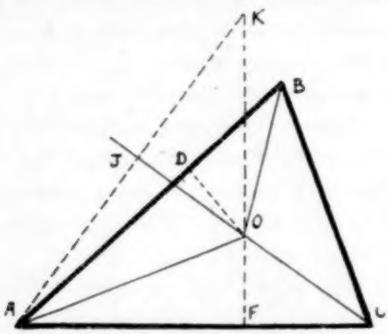
All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

LATE SOLUTIONS.

706. *By Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

The following solution is due to *Euler* about 1747-48.



In the figure, O is the center of the inscribed circle, OF and OD are perpendiculars, AJ is $\perp$ CO produced, and K is the intersection of AJ and FO.

Then $\angle AOJ = 1/2\angle BAC + 1/2\angle BCA = \angle DOB$, so that $\triangle AJO$ and $\triangle BDO$ are similar, and $AJ/JO = BD/r$. Combining this proportion with $AJ/JO = AC/OK$, which is derived from the similar $\triangle$s CJA, OJK, we get $BD \times OK = AC \times r$. But $OK = FK - r$, so that

(1) $BD \times FK = BD \times r + AC \times r = (BD + AC)r = sr.$

Since $\triangle$sCFO and KAF are similar, $FK \times r = AF \times CF$. Hence

(2) $BD \times FK \times r = sr^2 = BD \times AF \times CF$, or

$$s^2r^2 = s \times BD \times AF \times CF = s(s-a)(s-b)(s-c).$$

713. *F. Howard, San Antonio, Texas*, suggests that problem 713 was very likely meant to read *geometric* instead of *harmonic*. With this change, it is proposed as problem 731.

714. *F. Howard, E. Tabor, Upper Lake, California.*

715. *Nevada Tabor, Upper Lake, Union High School.*

SOLUTIONS OF PROBLEMS.

716. *Suggested by E. Tabor's solution of problem 703.*

For the series 1, 2, 3, 5, 8, 13, 21, 34, ...

in which $T_n = T_{n-1} + T_{n-2}$ prove:

$$T_{2n} = (T_n)^2 + (T_{n-1})^2 \text{ and } T_{2n-1} = (T_n)^2 - (T_{n-2})^2$$

I. *Solution by Michael Goldberg, Philadelphia, Pa.*

$$T_n = T_{n-1} + T_{n-2}$$
$$T_{n+1} = T_n + T_{n-1}$$
$$T_{n+2} = 2T_n + T_{n-1}$$
$$T_{n+3} = 3T_n + 2T_{n-1}$$
$$T_{n+4} = 5T_n + 3T_{n-1} \quad \text{etc.}$$

It is evident that the coefficients of the terms of the right hand member of the above equations have the same relation as that of the given series, since each term is formed by adding together the two preceding terms. Therefore,

$$\begin{aligned}
T_{n-n} &= (T_n)(T_n)+(T_{n-1})(T_{n-1})\\
T_{2n} &= (T_n)^2+(T_{n-1})^2\\
\text{And } T_{n+n-1} &= (T_{n-1})(T_n)+(T_{n-2})(T_{n-1})\\
&= (T_n-T_{n-2})(T_n)+(T_{n-2})(T_n-T_{n2-})\\
T_{2n-1} &= (T_n)^2-(T_{n-2})^2
\end{aligned}$$

II. *Solution by Norman Anning, Ann Arbor, Mich.*

$$\begin{aligned}
\text{Let}\quad a^2 &= a+1 = 1a+1\\
\text{Then}\quad a^3 &= a^2+a = 2a+1\\
a^4 &= 2a^2+a = 3a+2\\
a^5 &= \qquad = 5a+3 = T_4a+T_3\\
a_6 &= \qquad = 8a+5 = T_5a+T_4.
\end{aligned}$$

From these it is inferred, and by mathematical induction it may be proved that

$$a^n = T_{n-1}a+T_{n-2} \quad (n = 3, 4, 5, \cdot\ \cdot\ \cdot\ \cdot\ \cdot).$$

$$\begin{aligned}
\text{Then}\quad T_{2n+1}a+T_{2n} &= a^{2n+2} = (a^{n+1})^2\\
&= (T_na+T_{n-1})^2 = T_n^2(a+1)+2aT_nT_{n-1}+(T_{n-1})^2\\
&= [(T_n)^2+2T_nT_{n-1}]a+[(T_n)^2+(T_{n-1})^2].
\end{aligned}$$

Note that $a[= (1+\sqrt{5})/2]$ is irrational and, consequently, if l, m, p, q, are integers the statement that

$$la+m = pa+q$$

implies $l = p$ and $m = q$. For, if this were not the case, we would have the irrational a equal to the rational quantity, $(q-m)/(l-p)$.

Hence, $T_{2n} = (T_n)^2+(T_{n-1})^2$, $T_{2n+1} = (T_n)^2+2T_nT_{n-1}$.

When $n-1$ is put for n in the latter, it can be changed into the second of the two desired relations.

The same method can be used should we wish to prove

$$T_{3n-1} = (T_n)^3+(T_{n-1})^3-(T_{n-2})^3.$$

III. *By the Editor.* It is curious to see into what realms of mathematics we are frequently led by some problem. The above series, for example, arose from a problem which the Proposer had cut from a newspaper. A discussion of the nth term of the series is found in the American Mathematical Monthly, vol. 28, page 329.

Also solved by *F. Howard.*

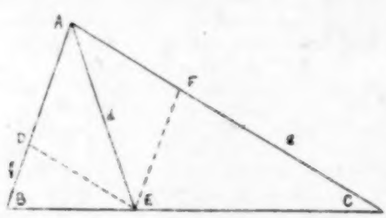
717. *Proposed by Daniel Kreth, Wellman, Iowa.*

Construct the triangle, given $\angle$A, the length d of the bisector of this angle, and the sum e of the including sides AB and AC.

Solution by H. R. Scheufler, Culver Military Academy, Culver, Ind.

Construct the given $\angle$A, bisect it, and make AE $= d$, the bisector. From E draw lines parallel to the sides of the given angle, forming the rhombus AFED. From e, which is the sum of AB and AC, subtract 2AD and then divide the remainder into two parts, f and g, such that AD will be a mean proportional between the two parts. Then AD $+f$ is AB, one side of the desired triangle; and AF $+g$ is AC, the other side.

The construction will be proved correct if we prove that BEC is a straight line, which can be done by proving $\triangle$s BDE and EFC similar. By construction BD/AD = AD/FC. But AD = DE = EF, so that BD/DE = EF/FC. Also $\angle$BDE = $\angle$EFC, and the triangles are similar.



Analytic solutions using trigonometry showing how AB and AC could be found by solving a quadratic were received from *Moe Buchman, student, College of the City of New York; Henry L. Wood, Boonton, N. J.;* and the *Proposer.* The following trigonometric solution, however, can easily be carried out.

II. *Solution by Michael Goldberg.*

The area of $\triangle ABC$ equals the product of $e/2$ and h, where h is the perpendicular from the end of d to either side. The area is also equal to $1/2 AB \times AC \sin A$. Hence $he \csc A = AB \times AC$. Accordingly, we first find x, the mean proportional between h and $e \csc A$. Then we divide the line e into two parts for which x will be the mean proportion. The two parts will be the desired lines AB and AC.

718. *Proposed by F. Howard, San Antonio, Texas.*

A clock has three hands, the hour, minute and the second, on the same pivot. What is the first time after 12 o clock when the hands will be equally distant?

I. *Answer by Elmer Schuyler.*

According to the following solution, given in Ghersi's Mathematica Dilettevole e Curiosa, it is impossible.

Let the hour hand be x minute spaces beyond XII, then the minute hand will be $x+20$ beyond XII, and the second hand be $x+40$; or, else the second hand is $x+20$, and the minute hand is $x+40$. In the first case, we must have

$$60n+x+20 = 12x$$
$$60n^1+x+40 = 720x$$

where n and n^1 are integers. Eliminating x, gives

$$(3n+1)/(3n^1+2) = 11/719 \quad \text{or} \quad 3(11n^1-719n) = 697.$$

But $11n^1-719n$ is an integer; then 697 must be divisible by 3 in order that the problem be possible.

The second case gives $3(11n^1-719n) = 1{,}427$ which is again impossible for the same reason.

Similarly explained by *Michael Goldberg*, and the *Proposer.*

Assuming that the problem meant that one hand should be midway between the other two, solutions were received from *T. E. N. Eaton, Redlands, Cal.; Arthur H. Lord, Lynn, Mass.; Edward Lewis*, 23, *Redlands H. S., Calif.; Daniel Kreth, Wellman, Iowa; Eva Tilton*, 23, *Redlands H. S.; A. M. Waas, Philadelphia, Pa.* After 59 13/73 seconds the hour hand is midway between the other two; and after one and 13/1427 minutes the second hand is between the other two.

719. *Proposed by Walter R. Warne, Pennsylvania State College, State College, Pa.*

A, B, C are three buoys; AB = 320, BC = 435, CA = 600. A ship S finds that AB subtends an angle of 8°, and BC an angle of 26°. How far is the ship from each of the buoys?

There are four possible solutions to this problem. *Michael Goldberg* was the only one to find the numerical values for all four cases; and *Daniel Kreth* showed the solutions for the general case when the sides are a, b, c, etc. Other solutions were by *Moe Buchman* (2 cases), *F. Howard* (2 cases), and *Karl Paul, Waubun School, Minn.* This problem deserves more space than can be given here, and so the editor has turned over all the solutions to *Daniel Kreth* with the suggestion that he write a special article for us about this problem. We hope it will appear shortly.

720. *For high school students. Proposed by the Editor.*

A can do a certain piece of work in 25 days, B in 22, C in 20 days. A starts on the job and after working 3 days, hires B to assist him; then three days later C also begins working. How soon is the job completed?

Solution by Lois A. Woodbury, Nashua H. S., New Hampshire.

	Days each works	Part of work each can do in 1 day	Total amount of work done by each
A	$6+x$	1/25	$(6+x)/25$
B	$3+x$	1/22	$(3+x)/22$
C	x	1/20	$x/20$

Since the total amount of work done is equal to the whole piece of work,

$$(6+x)/25+(3+x)/22+x/20 = 1; \quad x = 4.60+$$

Then, since A worked all the time, the time necessary to do the work was $6+x = 10.60+$ days.

Too many solutions have been received to be able to mention all the names. The best ones were: *Henrietta Humbert, Jerome, Ariz.; Ysabel Hastings and Austen Roach, Redlands, Calif.; Violet Lord, and Fred W. Peaslee, Nashua, N. H.;* and for solutions by arithmetic, *Olin W. Munger, Northeast H. S., Kansas City, Mo.; and Eric McCann, Grant's Pass, Oregon.* The chief faults of the poor solutions were that they contained such expressions as Let x = when C begins, or x = time to finish or the equation was stated with no explanation of how it was derived.

PROBLEMS FOR SOLUTION.

Solutions should reach the editor by the twentieth of the month following publication.

731. *Proposed by F. Howard, San Antonio, Texas.*

A geometric and an arithmetic progression have the same pth, qth, and rth terms, a, b, and c, respectively. Prove

$$a(b-c)\log a+b(c-a)\log b+c(a-b)\log c = 0.$$

732. *Proposed by Elmer Schuyler, Bay Ridge H. S., Brooklyn, N. Y.*

BCA is a diameter, CA = CB = 1. Draw the semicircle AGB, G being its midpoint. With A as a center, and AG for a radius, draw an arc cutting AB in D. With A as a center, and AC as a radius, draw an arc cutting the semicircle in M. Show that DM is approximately $\sqrt[3]{2}$. (*Peraux's* Approximation.)

733. *Proposed by Harris F. MacNeish, College of the City of New York.*

Find without using trigonometry the volume of a regular dodecahedron in terms of the edge e.

734. *Proposed by Norman Anning, Ann Arbor, Mich.*

If a, b, c are the roots of $x^3+x^2-2x-1 = 0$, show that $a^2b+b^2c+c^2a$ equals either 3 or -4.

735. *For high school students. Proposed by the Editor.*

Prove: the two common external tangents of two circles intercept on a common internal tangent a segment, CD, equal to the external tangent AB.

The examination below was received from John Lundberg, Goteborg, Sweden. To judge the nature of any work from an examination we need to know something about the age of the pupils, etc., and the following information has been furnished by C. R. Nilsson, Cleveland, Ohio, who is a graduate of the Goteborg schools and a former student at the University of Illinois.

The pupils enter at an average age of ten years. The work is divided into seven classes, a lower school of five classes and an upper school or "gymnasiet" of four classes called the lower and upper sixth and the lower and upper seventh. Thus the work covers nine years, and the pupil takes his graduating "Studentexamen" when he is nineteen. After finishing the lower school, the pupil must choose between the "Real gymnasiet" which prepares for business and technical schools, and the "Latin gymnasiet" which prepares for the professions of law, medicine or ministry. The examination below is for those ready to graduate from the Latin gymnasiet.

1. In a town, 125,250 different connections can be made over the telephone system. How many subscribers are there?
2. Separate 365 into two parts such that the sum of the square roots of the parts will be 27.
3. Three numbers whose sum is 31 form a geometric progression. If the second term is increased by 8, the numbers will form an arithmetic progression. Find the numbers.
4. A stream of light in the shape of a cone lights up one-third of the surface of a sphere whose radius is r. How far from the surface of the sphere is the vertex of the cone?

5. Express the cube root of the repeating decimal 4.629629, as a repeating decimal.

6. In the isosceles trapezoid ABCD, AB = 9.46 is parallel to CD = 7.13. Angle ABC = 72°. Find the lengths of the diagonals.

7. The logarithm of a number to the base 10 equals the sum of its logarithms to two other bases, of which one base is one-tenth of the other. What are the two bases?

8. For a pail shaped like the frustum of a cone, the areas of the bases are 15 dm.^{2} and 10 dm.^{2} and the height is 12 dm. The pail contains water at a temperature of 4°. What is the pressure on the bottom?

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Foreign Examination Papers.

The *Editor* of this department is not discouraged by failure to obtain responses to his request for foreign examination papers. Did not Mr. John Lundberg of Goteborg send some examinations from Sweden? Speaking mathematically the chance of obtaining the papers desired from France, Italy, Spain, Belgium, Norway, Denmark and other countries is increasing—the event is bound to happen some time, hence each month that passes without a favorable reply increases the Editor's chance of obtaining the papers the next month.

Once more, readers of SCHOOL SCIENCE AND MATHEMATICS in the countries mentioned above, please send examination papers to the Editor or inform him how they may be obtained through book sellers or education departments.

Do the universities of India give entrance examinations?

Problems for Solution.

389. *From an advertisement in The Country Gentleman.*

(1) What is the mechanical advantage of the PULLEY system in this stump puller?

(2) Adopt values for length of lever and toggle where fixed end of lever is attached, also for push of a 180-pound man and figure the force produced at the stump?

390. *Submitted through Mr. Charles M. Turton.*

A vessel contains 11.83 cu. ft. of air at a pressure of 33.3 lb. per sq. in. It is desired to increase the pressure to 40 lb. per sq. in. by supplying air from a second vessel which contains 19.6 cu. ft. of air at a pressure of 60 lb. per sq. in.

What will be the pressure in the second vessel after the first has been increased to 40 lb. per sq. in.?

Examination Papers.

The following paper in Physical Science completes the set of science papers from the Province of Alberta whose publication was undertaken in the course of the past year or more.

This set of papers deserves careful study, representing as it does the course of study in science in Alberta schools.

PROVINCE OF ALBERTA.

HIGH SCHOOL AND UNIVERSITY MATRICULATION EXAMINATIONS BOARD, DEPARTMENTAL EXAMINATIONS, 1920.

GRADE XII.—PHYSICAL SCIENCE.

Time—Two and one-half hours.

Values.

4 **1.** (*a*) Define the terms: dyne, erg, kilowatt, horsepower.

4 (*b*) Compare the kinetic energy of a ton truck moving at the rate of 15 miles an hour with that of an automobile of 1,500 pounds weight moving at the rate of 20 miles an hour.

6 (*c*) Show, using a diagram, how a system of pulleys may be arranged so that, neglecting friction, a body weighing 900 pounds may be raised by applying a force of 150 pounds.

4 **2.** (*a*) By reference to the relation between pressure and depth in a liquid, demonstrate how great must be the buoyant force of a liquid on a body immersed in it.

4 (*b*) What is the rate of pressure measured in kilograms per square dm. at a depth of 4 m. in a pond if the barometer stands at 75 cm. and the specific gravity of mercury is 13.6?

3. Write a note on the molecular theory showing how it helps to explain the following:

2 (*a*) The unequal rates of diffusion of gases through a porous partition.

2 (*b*) The expansion of a solid when heated.

2 (*c*) The magnetization of a bar of iron.

4 **4.** (*a*) (1) Describe the movements of air particles when transmitting sound.

2 (2) Explain the presence of a node in the vibrating air column of a tube open at both ends.

6 (*b*) Describe an experiment to illustrate the conditions under which beats may be produced. Explain this phenomenon.

4 (*c*) Show by reference to musical instruments:

(1) How the laws of transverse vibrations of strings are applied in producing notes of different pitch.

4 (2) How the intensity of the sounds produced is increased by consonance.

6 **5.** (*a*) Describe an experiment to show how the heat of vapourization of water may be determined.

4 (*b*) Show by reference to the turbine engine how the energy

of steam produced at high pressure is transformed to mechanical motion.

8 (*c*) Describe the construction of a simple cold storage plant and show how the fact that heat is required to change a liquid to a vapour is applied in this method of reducing the temperature of a cold storage room.

6. (*a*) Show by means of diagrams the position and relative magnitude of the image in each of the following cases:

3 (1) An object is placed 6 inches from a concave mirror the focal length of which is 4 inches.

3 (2) An object is placed between a convex lens and its principal focus.

3 (*b*) (1) Why is a spectrum formed when white light is passed through a prism?

6 (2) How may the existence of rays beyond the violet and red of the visible spectrum be demonstrated?

7. "One of the most important achievements from the study of light has been the production of optical instruments which have been invaluable in the advancement of science."

4 (*a*) By reference to examples demonstrate the truth of this statement.

8 (*b*) Describe the construction and action of either the projection lantern or the compound microscope.

6 **8.** (*a*) Describe the construction of an instrument for measuring current strength in which the strength of the current is determined by its magnetic effects.

6 (*b*) How may the resistance of the armature of a dynamo be measured?

6 (*c*) Calculate the cost per day of lighting a factory if 500 lamps of 16 candle power are used 6 hours during the day and each lamp requires 1-2 ampere in a 110 volt circuit, the cost of electricity being 8 cents per kilowatt hour.

4 **9.** (*a*) How have the conditions necessary for the production of an induced current been fulfilled in the dynamo?

6 (*b*) How do series wound and shunt wound dynamos differ? State the conditions under which each would be used.

4 (*c*) If a multipolar alternating current dynamo has 8 poles and the armature makes 240 revolutions per minute, calculate the number of alternations of the current per second.

125

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for November, *Brooklyn Botanic Garden*, $6.00 *per year*, 75 *cents a copy*. "The Interrelationship of the Number of the Two Types of Vascular Bundles in the Transition Zone of the Axis of Phaseolus Vulgaris," J. Arthur Harris, Edmund W. Sinnott, John Y. Pennypacker and G. B. Durham; "Area of Vein-Islets in Leaves of Certain Plants as An Age Determinant, M. R. Ensign; "Unusual Rusts on Nyssa and Urticastrum," E. B. Mains; "Miscellaneous Studies on the Crown Rust of Oats," G. R. Hoerner; "Comparative Studies on Respiration XVIII—Respiration and Antagonism in Elodea," C. J. Lyon; "The Effect Upon Permeability of (1) the Same Substance as Cation and Anion, and (II) Changing the Valency of the Same Ion," Oran L. Raber.

American Forestry, for January, *Washington, D. C.*, $4.00 *per year*, 40 *cents a copy*. "Seeds of International Friendship," Arthur N. Pack; (twelve illustrations); "Botanic Garden and Arboretum for the Nation," W. R. Mattoon, (four illustrations); "The Maples," J. S. Illick; (fourteen illustrations); "The Foundation for Forestry in New Jersey," C. P. Wilber,

(six illustrations); "To Use Alaska's Forests;" "How Skunks Defend Themselves," R. W. Shufeldt; (ten illustrations); "Forest Recreation Department—Minimum Requirements in Recreation," Arthur H. Carhart, (ten illustrations).

Geographical Review, for January, *Broadway at 156th Street, New York City, $5.00 per year, $1.25 a copy.* "The Hwang Ho, Yellow River," Frederick G. Clapp, (1 map, 7 photographs); "The Geographical Factor in the Development of Chinese Civilization," Carl W. Bishop, (2 maps, 12 photographs); "Exploration in the Land of the Yuracarés, Eastern Bolivia," Kirtley E. Mather, (1 map, 6 photographs); "Notes on the Forests of Southeastern Labrador," E. M. Kindle, (2 maps, 9 photographs); "A Map of the Distribution of Population in Sweden: Method of Preparation and General Results," Sten de Geer, (2 maps); "The Geographical Characteristics of Western France," René Musset, (2 maps, 3 diagrams); "Climatic Provinces of the Russian Far East in Relation to Human Activities," Stanislaus Novakovsky, (2 maps, 1 diagram); "Composite Temperature Types of the United States," Robert DeC. Ward, (12 diagrams); "The Evolution of Climate in North-Western Europe: A Review," Ellsworth Huntington.

Journal of Geography, for December, 2249 *Calumet Ave., Chicago, $2.50 per year, 25 cents a copy.* "The Relation of Geography to the Writing and Interpretation of History," Harry E. Barnes; "The Port of New Orleans," Edna Campbell; "Home Geography and History by the Problem Method," Alice M. Krackowizer.

National Geographic Magazine, for January, *Washington, D. C., $3.50 per year, 50 cents a copy.* "The Islands of Bermuda," (16 illustrations), William Howard Taft; "Certain Citizens of the Warm Sea," (34 illustrations), Louis L. Mowbray; "The Land of the Basques," (26 illustrations), Harry A. McBride; "The Geography of Our Foreign Trade," (25 illustrations), Frederick Simpich.

Photo-Era, for December, *Boston, Mass., $2.50 per year, 25 cents a copy.* "Florida Impressions," Thomas S. Carpenter; "Selling Your Photographs," Frederick C. Davis; "My First Photograph," Emily H. Hayden; "Illustrated Advertising," Photographische Industrie; "Desensitising Autochrome Plates," A. and L. Lumière and A. Seyewetz; "Amateur-Opposition," The British Journal.

Popular Astronomy, for January, *Northfield, Minn.*, $4.00 *per year.* "Pulkovo Observatory from a Dirigible," "Astronomical News from Russia;" "Twenty-Sixth Meeting of the American Astronomical Society," Abstracts of Papers Concluded; "Report on Mars, No. 24," William H. Pickering; "The Node of Solar Eclipses," Arthur Snow; "Astronomical Phenomena in 1922."

School Review, for December, *University of Chicago Press*, $2.50 *per year*, 30 *cents a copy*. "Bases on Which Students Can Be Classified Effectively," Frank N. Freeman; "Free Secondary Education," J. D. Rheinallt Jones; "Teaching a Study-Habit—II," Ralph E. Carter; "Caring for Highly Endowed Pupils," John Louis Horn; "General Intelligence, Machine Shop Work, and Educational Guidance in the Junior High School," Verne A. Bird and L. A. Pechstein.

Scientific Monthly, for January, *Garrison, N. Y.*, $5.00 *per year*, 50 *cents a copy*. "Hybridization in Plant and Animal Life," Dr. D. F. Jones; "Adventures in Stupidity—a Partial Analysis of the Intellectual Inferiority of a College Student," Professor Lewis M. Terman; "Certain Unities in Science," Professor R. D. Carmichael; "Thomas Hariot," Dr. F. V. Morley; "Dru Drury—an Eighteenth Century Entomologist," Professor T. D. A. Cockerell; "Galen: The Man and His Times," Professor Lynn Thorndike; "The Mortality of Foreign Race Stocks," Dr. Louis I. Dublin.

ANNOUNCEMENT OF MEETING OF NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS, AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND LITTLE LABORATORY, SATURDAY, FEBRUARY 11, 1922.

The seventy-fifth meeting of the New England Association of Chemistry Teachers promises to be one of unusual interest.

The morning session will be held at the Massachusetts Institute of Technology, beginning at 10 a. m. Dr. William T. Bovie, Professor of Biophysics at the Harvard Medical School, will speak on some topic related to the modern conception of atomic structure and Mr. McAllister, expert glass blower for the Physical Department of Harvard University, maker of X-ray apparatus, etc., will give a demonstration in elementary glassblowing. Mr. McAllister will explain and illustrate how to make closed tubes, bulbs, funnels, thistle tubes, Ts and other apparatus requiring special skill in their construction.

Following the lunch and social hour at the Walker Memorial, where a private room will be had for the use of the Association, an afternoon session will be held at the laboratory of Arthur D. Little, Incorporated. Here Dr. Arthur D. Little will address the Association on "Energy, Its Sources and Possibilities." At the afternoon session, also, a Symposium of Lecture Table Demonstrations of Teaching Experiments in Chemistry will be shown by several college and secondary school teachers of chemistry.

The meeting will conclude with a conducted trip through the Little Laboratories.

All persons interested in chemistry, especially teachers of chemistry, are invited.—[S. Walter Hoyt, Secretary, 20 Stone Road, Belmont, Massachusetts.

January 7, 1922.

To promote correct speech, Smith College examines every entering freshman in oral English. Any student who does not come up to the standard in pronunciation, etc., must take a course in the department of spoken English.—*School Life*.

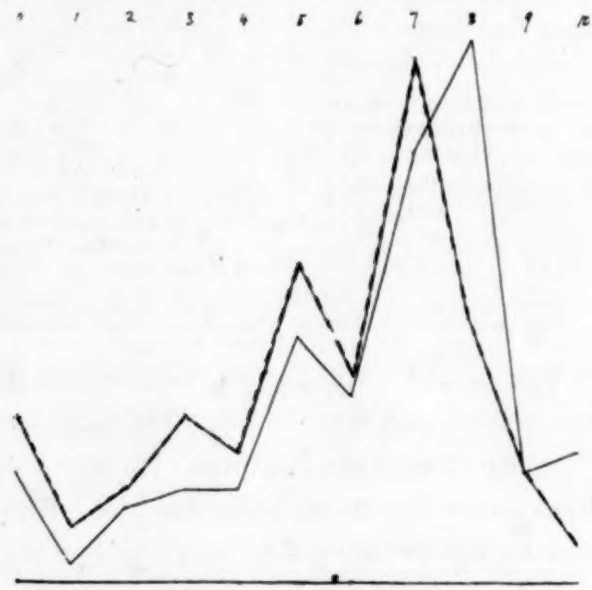
ERRATUM.

Owing to a delay in the mails, the accompanying figures and graphs to go with the article entitled "An Experiment in the Use of Three Different Methods of Teaching in the Class Room," by George W. Hunter, were omitted from the January issue. The first graph made from the combined statistics of the four test series, making up the experiment "An Attempt to Determine the Relative Value of Visual and Oral Instruction in Demonstration or Experimental Work in Elementary Biology" should be inserted at line 26 on page 28. The subsequent graphs should be inserted after line 37 on page 31 of the same article.

TOTAL RESULTS OF FOUR DIFFERENT LESSONS. TWO CLASSES; TWO DIFFERENT METHODS

Method	Results										
	0	1	2	3	4	5	6	7	8	9	10
Oral Demonstration of Experiment	6	1	4	5	5	13	10	23	29	6	7
Visual Demonstration of Experiment	9	3	5	9	7	17	11	28	14	6	2

Oral Demonstration ———
Visual Demonstration— — — — — —



Average Mark-Oral 6.29
Average Mark-Visual 5.41

SAME LESSON; TWO CLASSES; TWO DIFFERENT METHODS

Method	Results										
	0	1	2	3	4	5	6	7	8	9	10
Class 108 Developmental Laboratory Lesson	5	1	7	5	4	2	3	3	1	0	0
Class 127 Laboratory Lesson with Laboratory Manual	3	8	5	4	4	0	2	0	0	0	0

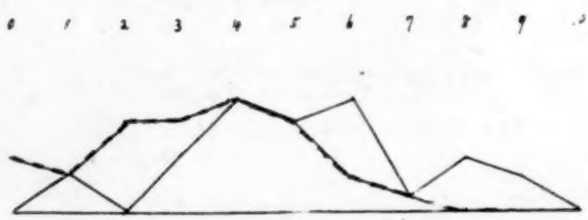
CLASS 108—DEVELOPMENTAL———
CLASS 127—LABORATORY MANUAL— — — —

CLASS 108—DEVELOPMENTAL—AVERAGE MARK 3.3
CLASS 127—LABORATORY MANUAL—AVERAGE MARK 2.2

SAME LESSON; TWO CLASSES; TWO DIFFERENT METHODS

Method	Results										
	0	1	2	3	4	5	6	7	8	9	10
Class 122 Oral Laboratory Demonstration	0	2	0	3	6	5	6	1	3	2	0
Class 108 Lesson with Laboratory Manual	3	2	5	5	6	5	2	1	0	0	0

Oral Laboratory——————
Laboratory Manual — — — — — —



CLASS 127—ORAL LABORATORY—AVERAGE MARK 5.1
CLASS 108—LABORATORY MANUAL—AVERAGE MARK 3.2

NEW OIL AND GAS MAP OF PENNSYLVANIA.

The latest addition to the Geological Survey's series of maps showing the oil fields in the States of the Union is the map of Pennsylvania. This map agrees with others of the series in showing the features of greatest interest to oil and gas operators in distinctive colors and the purely geographic features in a subdued black. The oil fields are shown in green, the gas fields in red, and the pipe lines and refineries in violet, but the cities towns, streams, railroads, etc., are shown in the subdued black.

The map shows strikingly the comparatively small part of the State that is producing oil and also the zonal arrangement of the oil and gas fields, with a broad belt that yields much gas and little oil lying east of a similar broad belt that yields oil with only a little gas.

The scale of the map is 1,500,000, or about 8 miles to the inch, and its dimensions over all are about 2¼ by 3½ feet. It may be obtained from the Director, U. S. Geological Survey, Department of the Interior, Washington, D. C., at a cost of 50 cents a copy.

A BIG LOST LAKE IN NEVADA.

During comparatively recent geologic time a great lake flooded a number of the valleys in northwestern Nevada. This lake has now almost completely disappeared, but geologists have named it, in its entirety, Lake Lahontan, in honor of Baron La Hontan, one of the early explorers of the headwaters of the Mississippi. At the time of its greatest expansion, according to the United States Geological Survey, Department of the Interior, this ancient lake covered 8,400 square miles. The deepest part of Lake Lahontan, which was 880 feet deep, was the site of the present Pyramid Lake, one of its remnants, so that its surface stood about 500 feet above the surface of Pyramid Lake. The ancient lake had no outlet except the one that led straight up, its waters being dissipated entirely by evaporation.

A large area a few miles north of Winnemucca, Nev., is covered with sand dunes that were formed since Lake Lahontan disappeared. These dunes are fully 75 feet thick, and their steeper slopes are on the east side, indicating that the whole vast field of sand is slowly traveling eastward. The march of this sand is irresistible, and its progress has necessitated a number of changes in the roads in the southern part of Little Humboldt Valley during recent years. In some places in this region the telegraph poles have been buried so deep that they have had to be spliced in order to keep the wires above the crests of the sand dunes. The sand is of a light creamy-yellow color and forms beautifully curved ridges and waves that are covered with an artistic fretwork of wind ripples.

ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Auditorium, Soldan High School, St. Louis, Mo.,
November 25 and 26, 1921.

Promptly at ten o'clock the annual meeting was opened with music by the Soldan High School Orchestra.

The program was carried out according to announcement:

Address of Welcome, John Rush Powell, Principal Soldan High School, St. Louis.

Response for the Association, Chas. H. Smith, Assistant Principal Hyde Park High School, Chicago, Ill.

Announcements, Walter W. Hart, President of the Association.

Address, "Sound Pedagogy," Chancellor Frederick A. Hall, Washington University, St. Louis.

Address, "Half Learning and the Way Out," Professor Henry C. Morrison, University of Chicago.

These addresses are published in the official journal, SCHOOL SCIENCE AND MATHEMATICS.

The afternoon was devoted to the section meetings and an informal reception in charge of the local reception committee headed by Miss Edith Glatfelter, Soldan High School, St. Louis.

EVENING SESSION, AMERICAN ANNEX HOTEL, ST. LOUIS.

At 7 p. m. the members met with the American Mathematical Society and the Mathematical Association of America for dinner at the American Annex Hotel. Following the dinner the following program was rendered:

Address, "Age of Power," Professor Alexander S. Langsdorf, Crunden Martin Co., St. Louis.

Address, "Zoology in the Secondary Schools," Professor Caswell Grave, Washington University, St. Louis.

Movies, three reels furnished by the Society for Visual Education: 1. Stages in the development of the frog and some of the habits of frogs and toads; 2. Definitions and suggested proofs in plane geometry; 3. Astronomy: stellar phenomena, comets, nebula, motions and phases of the moon, motions of the earth, etc.

We regret to announce that Dean G. O. James, Washington University, St. Louis, who was to have delivered an address on "The Artificial Order of Nature," was called out of the city because of illness of a member of his family.

About two hundred attended the dinner and thoroughly enjoyed the scientific observations of Professor Langsdorf and the amusing stories of Professor Grave.

SATURDAY SESSION, SOLDAN HIGH SCHOOL.

At 10 a. m. the various sections resumed their work of the previous day. In the afternoon excursions were taken to the following places of scientific interest: 1. Missouri Botanical Garden; 2, Chain of Rocks ten miles north of the city; 3, Commonwealth Steel Company; 4, The Laclede Gas Plant; 5, The Cahokia Mounds near East St. Louis, Ill.; 6, The City Art Museum, the Thomas Jefferson Memorial Building and the Forest Park Zoo; 7, The Illinois Glass Company, Alton, Ill.

ANNUAL BUSINESS MEETING, SOLDAN HIGH SCHOOL, SATURDAY, NOVEMBER 26, 1921, 9:00 A. M.

President Hart presiding called for the annual reports of the officers and standing committees.

The Treasurer, Mr. Hall, gave the financial report included below, which, following a provision made by the executive committee, covers transactions from September 1, 1920, to September 1, 1921. Mr. Newell, chairman of the auditing committee, reported the books correct to September 1, 1921. Reports approved.

The report of the committee on necrology, prepared by Mr. Isenbarger, was read by the Secretary, all members of the committee being absent.

No formal report of the advertising committee was made at this time because many of the bills had not been collected, but statements made by Mr. Kelsey and Mr. Hart showed that the receipts from advertising would amount to about $800.

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The membership committee, in charge of Mr. Webb, reported mailing out over five thousand circulars and Mr. Hall reported about 450 paid memberships to date.

In the absence of Mr. Cobb of the resolutions committee Mr. Gillet gave the report recorded below, which was approved, and the Secretary was directed to write letters of thanks and appreciation to the speakers who had contributed to the success of the general meetings.

Mr. Ammerman, chairman of the nominating committee, reported the following nominations: President, Alfred Davis, Soldan High School, St. Louis; Vice-President, Theodore Harley, Hyde Park High School, Chicago; Secretary (elected in 1920 for two years); Treasurer, Jerome B. Isenbarger, Nicholas Senn High School, Chicago; Assistant Treasurer, Garfield A. Bowden, University School, Cincinnati; Cor. Secretary, Ada Weckel, Oak Park Tp. High School, Oak Park, Ill. The report was adopted and the Secretary directed to cast the unanimous vote of the association for these nominees.

Mr. Davis, the incoming President, was called upon and responded briefly, thanking the Association for the honor conferred upon him.

On motion of Mr. Turton a vote of thanks was tendered Mr. Hall for efficient services for two years as Treasurer.

The following proposed amendment to the constitution which had been printed in the October number of the official journal, as required, was unanimously adopted.

"The dues of active and associate members shall be two dollars and fifty cents ($2.50) per year, payable at the annual meeting for the following year. Members in arrears for one year shall be dropped from the list of membership."

The following amendment to the constitution was proposed and referred to the incoming executive committee.

"We recommend that memberships in the Central Association of Science and Mathematics Teachers be accepted as follows:

"1. Individual memberships, active and associate, at $2.50, which shall include SCHOOL SCIENCE AND MATHEMATICS for one year.

"2. Institutional memberships, giving one representative from the institution the full rights of active membership, at $2.50, which shall include SCHOOL SCIENCE AND MATHEMATICS for one year.

"3. Individual memberships, active or associate, at $1.00 a year.

"All members shall receive a copy of the proceedings of the annual meeting."

The President called for a report from a special committee which had been appointed by order of the executive committee, October 1, 1921. In the absence of the chairman, Dr. Elliot R. Downing, Mr. Newell responded stating that this committee recommends the appointment of an outlook committee, the duty of which shall be to investigate the modern trend of education and make recommendations to the executive committee and the Central Association from time to time. Further explanation was made by Mr. Gillet who presented the following motion:

We recommend that the executive committee appoint an outlook committee consisting of

1. A chairman to be appointed by the President of the Association with the approval of the executiye committee.

2. One member from each section to be appointed by the chairman of that section with the approval of the chairman of the outlook committee.

3. As many other members as seems advisable to be appointed by the President of the Association with the approval of the executive committee.—[Glen W. Warner, Secretary.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Be It Resolved:

1. That the Association expresses its thanks to the Board of Education of the city of St. Louis for the use of this magnificent building, to the principal, teachers, and pupils of the Soldan High School who have made such hospitable arrangements for the comfort of the members and guests of the association, and for the continued courtesies during the annual meeting; to the committees on local arrangements, membership, publicity, program, and entertainment for their effective services.

2. That the association expresses its appreciation of the competent administration of President Walter W. Hart during the past year. By his untiring devotion and tactful guidance he has greatly increased the value of the Association to teachers of science and mathematics.

3. That the Secretary express in writing the thanks and appreciation of the Association to Chancellor Frederick A. Hall, Professor Alexander S. Langsdorf, Professor Henry C. Morrison, and Professor Caswell Grave for their forceful and interesting addresses at the general sessions. Also to Dean C. O. James for his kind acceptance of the invitation of the Association, and our deep regret that the sudden illness of a member of his family made it impossible for him to be present.

4. That the Association, in view of its unique position in this country as an assembly of teachers of science and of mathematics, give more earnest consideration to the mutual relations of the different branches of science, and especially to the interrelations of science and mathematics. One of the most vital problems of the present time is to awaken the interest of teachers to the necessity of preparing pupils to apply readily their knowledge of mathematics to problems that later arise in laboratories, shops, in business, and in the genral affairs of daily life.—[H. E. Cobb, Chairman.

REPORT OF THE COMMITTEE ON NECROLOGY.

Information has come to your Committee on Necrology during the past year concerning the deaths of five members of the Association. Miss Grace Baird, of the Bowen High School, Chicago, died February 22, 1921, after an illness of only one week. Mr. Charles E. Lowman, of the Elgin, Ill., High School, was taken in January, 1920, by influenza. Professor William Rinck, of Calvin College, Grand Rapids, Michigan, was killed with his son in an automobile accident on Armistice Day, November 11, 1920. Professor Homer L. Roberts, of the Southeast Missouri State Teachers' College, was drowned August 23, 1921, in Current River, Shannon County, Missouri, while on a vacation trip, while he and Mrs. Roberts were doing research work. Dr. Edgar W. Stanton, Vice-President of Iowa State College and Dean of the Junior College of that institution, died at Canandaigua, N. Y., September 12, 1920.

REPORT OF CHEMISTRY SECTION, C. A. S. AND M. T.

The Chemistry Section met in Room 105 of the Soldan High School at 1:30 p. m., Friday, November 25, 1921. About 30 members were present. Owing to the absence of the chairman, the vice-chairman, G. A. Bowden, presided over the Chemistry Section.

The program consisted of the following:

"A History of the C. A. of S. and M. T. with special reference to the Chemistry Section," Sherman L. Kell, Senn High School, Chicago.

"The Purpose and Nature of a High School Course in Chemistry," Robert Fischer, McKinley High School, St. Louis.

"Testing Laboratory Resourcefulness," Dr. Hanor A. Webb, Associate Professor of Chemistry, George Peabody College for Teachers, Nashville.

"An Industrial Chemist in the Making," Dr. W. N. Stull, Mallinckrodt Chemical Company, St. Louis.

An informal discussion of the papers followed the program. Mr. Bowden appointed the nominating committee consisting of Dr. Hanor A. Webb, chairman, H. L. Tschentke, and Maude L. Sheldon.

SATURDAY MORNING, NOVEMBER 26, 1921.

The committee on nominations reported as follows: Chairman, S. R. Powers, College of Education, University of Minnesota, Minneapolis; vice-chairman, R. F. Holden, St. Louis; secretary, Lummie Lynch, Centralia High School, Centralia.

It was moved and seconded that the secretary cast the ballot of the section fo: these candidates. The motion was carried.

The following program was then given:

"A Study of the Achievement of High School Students in Chemistry," S. R. Powers, College of Education, University of Minnesota, Minneapolis, Minn.

"Colloids," Professor H. L. Ward, Department of Physical Chemistry, Washington University, St. Louis.

"The Project Method in High School Chemistry," Ellinor Garber, Shortridge High School, Indianapolis.—[J. Aaron Smith.

GENERAL SCIENCE SECTION, C. A. S. AND M. T.

FRIDAY SESSION, NOVEMBER 25, 1921.

The session opened at 1:40 with Mr. C. S. Webb in the chair, it having been moved, seconded, and carried that he accept the chair in the absence of both the chairman and vice-chairman. After several announcements, the section proceeded with the program as planned:

"Is General Science Destined to Go Down to the Junior High School?" Dr. John C. Hessler, Assistant Director, Mellon Institute.

"Project Method in General Science," G. A. Bowden, University School, Cncinnati, Ohio.

"General Science in the Elementary Grades of St. Louis," L. M. Dougan, Principal Field School, St. Louis, Mo.

"General Science from the University Point of View," H. A. Hollister, University of Illinois, Urbana, Ill.

At 4:20 the chair appointed, as the nominating committee of the General Science section with instructions to meet with the nominating committees of the other sections of the C. A. S. and M. T., the following: Mr. W. F. Roecker, Milwaukee, Wis.; Miss Philipine Crecelius, St. Louis, Mo.; Mr. John C. Hessler, Galesburg, Ill.

On motion the meeting adjourned until 10 o'clock Saturday.

SATURDAY SESSION, NOVEMBER 26, 1921.

The meeting was called to order at 10:15 with Mr. C. S. Webb presiding. The report of the nominating committee was then called for. Mr. Roecker reported as follows: Mr. C. S. Webb, chairman, Soldan High School, St. Louis, Mo.; Mr. Charles Fleming, vice-chairman, High School, Sandusky, Ohio; Miss Nina M. Gates, secretary.

It was moved seconded, and carried that the report be accepted.

The program as announced was then followed:

"General Science as a Preparation for Citizenship," G. W. Hunter, Knox College, Galesburg, Ill.

"Should General Science be Accompanied by a Large Amount of Individual Laboratory Work?" B. G. Shackelford, Principal Mullanphy School, St. Louis, Mo.

Back numbers of School Science, School Mathematics, and School Science and Mathematics may be had for 30 cents a single copy. The Mathematical Supplements for 15 cents a copy.

In sets the prices are, postpaid:

School Mathematics and Supplements, Vol. I, five numbers	$1.00
School Science, Vol. I, eight numbers	6.00
School Science, Vols. II and III, each	6.00
School Science, Vol. IV, three numbers	.75
School Science and Mathematics, Vols. V, VI, VII, VIII, IX X, XI, XII, XIII, XIV, XV, XVI and XVII, each	2.00
School Science and Mathematics, Vols. XVIII, XIX, XX and XXI, each	2.50

"Are Any Principles of Organization of General Science Evidenced by the Present Textbooks in the Subjects?" Ada Weckel, Oak Park and River Forest Township High School, Oak Park, Ill.

At 11:50 it was moved, seconded, and carried that the section extend a vote of appreciation and thanks to those on the section's program.

At 11:55 the meeting adjourned.

MINUTES OF THE GEOGRAPHY SECTION, C. A. S. AND M. T.

November 25, 1921.

The meeting was called to order by the chairman, Fred K. Branom.

The following program was submitted:

"Aims of Geography Teaching," James H. Smith, Assistant Principa Austin High School, Chicago, Ill. Mr. Smith not being present, his paper was read by Miss Waco.

"The Teaching of Place Geography," Douglas C. Ridgley, Illinois State Normal University and University of Chicago.

"The Use of Local Material in Geography Teaching, Illustrated," Clarence Bonnell, Harrisburg High School, Harrisburg, Illinois.

"Geography and Socialization," William Wade Walters, Principal Ashland School, St. Louis, Mo.

Announcements concerning the joint banquet of the Central Association of Science and Mathematics Teachers, the Southwestern Section of the American Mathematical Society, and the Missouri Section of the Mathematical Association of America were made.

Mr. Mendel E. Branom opened the discussion of Mr. Walter's paper. Mr. Walters had stated that in his opinion J. Russell Smith's, "Human Geography." First Book, is all that is necessary in the grades—that there is no place there for the second book. Mr. Branom asked Mr. Walters what he would do with the Second Book.

Mr. Walters answered that he would use it as a reference in the grades, and as a text book in the high school geography. He claims that the second book contains many experiences that grade pupils cannot understand, and even if they can understand they cannot appreciate them.

The chair appointed the members of the Nominating Committee as follows: D. C. Ridgley, University of Chicago, Chairman; Stanislaus R. Arseneau, Northern Illinois State Teachers' College, DeKalb, Ill.; Mabel Washburn, Shortridge High School, Indianapolis, Ind.

The meeting was adjourned.

November 26, 1921.

The meeting was called to order by the chairman, Mr. Branom.

The Nominating Committee reported, and the following officers were elected for next year:

Chairman, Robert G. Buzzard, State Teachers' College, DeKalb, Illinois.

Vice-Chairman, I. N. Van Hise, Hyde Park High School, Chicago, Illinois.

Secretary, Mabel Washburn, Shortridge High School, Indianapolis, Indiana.

Mr. Warner made announcements concerning the auto excursion.

The following program was submitted:

"Geography After General Science," Ira N. Van Hise, Chicago, Ill. Mr. Van Hise was not present, and his paper was read by Mr. Arseneau.

"The Project Method of Teaching Geography," Wendel E. Branom, Harris Teachers' College, St. Louis, Mo.

Miss Gladfelter asked that future meetings of this section concern themselves more with the problems of Secondary School Georgaphy.

Miss Ridgley seconded Miss Gladfelter's move, and suggested a return to discussions of all phases of high school geography—the course, classroom methods, in short, the "how" of teaching geography in the high school.

The meeting was declared adjourned by the chairman.—[Stanislaus R. Arseneau, Acting Secretary.

BOOKS RECEIVED.

Biology for Beginners, by Truman J. Moon, High School, Middletown, N. Y. Paper x+558. 13x19cm. Cloth. 1921. $1.60. Henry Holt and Co., New York City.

Public Education in Kentucky, General Education Board. Pages ix+213. 13×20 cm. Paper. 1921. General Education Board, 61 Broadway, New York City.

Program and Proceedings, First Pan-Pacific Press Conference, Honolulu, by Dr. Frank F. Bunker, Secretary. 96 pages. 17.5×25 cm. Paper. 1921. Honolulu Star-Bulletin.

Program and Proceedings, First Pan-Pacific Educational Conference, Honolulu, by Dr. Frank F. Bunker, Chairman, Pub. Com., Bureau of Education, Washington, D. C. 247 pages. 17.5×26 cm. Paper. 1921.

State Laws and Regulations Governing Teachers' Certificates, by Katherine M. Cook, Bureau of Education. 244 pages. 15×23 cm. Paper. 1921. Government Printing Office, Washington.

Report of the Commissioner of Education. Pages 42. 15×23 cm. Paper. 1921. Government Printing Office, Washington.

Opportunities for Study at American Graduate Schools, by George F. Zook and Samuel P. Copen. Pages 59. 15×23 cm. Paper. 1921. Government Printing Office, Washington.

General Science Instruction in the Grades, by Hanor A. Webb, Peabody College for Teachers. 105 pages. 15×23 cm. Paper. 1921. Peabody College for Teachers, Nashville, Tenn.

Games and Play for School Morale, by Mel. Sheppard and Anna Vaughn 31 pages. 14×22 cm. Paper. 1921. Community Service, New York City.

Public Education in North Carolina, a Report to the Public School Commission of North Carolina. 137 pages. 13.5×20 cm. Paper. 1921. General Education Board, 61 Broadway, New York.

Causes and Prevention of Fires and Explosions in Bituminous Coal Mines, by Edward Steidle. 14.5×23 cm. Paper. 1921. 20 cents. 107 half-tones. Government Printing Office, Washington, D. C.

BOOK REVIEWS.

Elementary Algebraic Geometry, by George W. Myers, The University of Chicago. 12×18 cm. Pages 111. Price, $1.00. 1921. Scott, Foresman & Co., Chicago.

To those who are interested in teaching mathematics to young people in a way that will enable them to use their knowledge of mathematics readily in any field where computations are required, it seems unfortunate that the year's work in geometry should continue to be given in a traditional manner. To the writer the statement made so often, that geometry is entirely different from arithmetic and algebra, means nothing; and when teachers who make this statement continue to give a whole year to logic, correct thinking, or mental discipline by proofs of geometrical theorems and exercises, it seems to him a stupid waste of the time and efforts of students.

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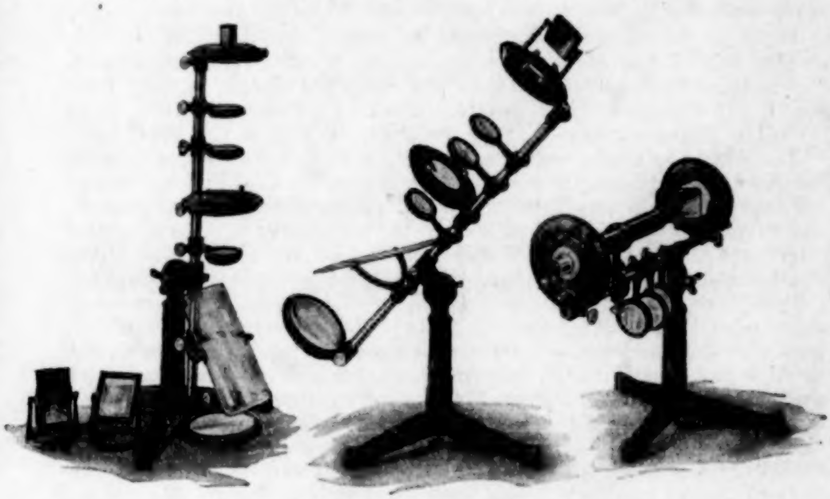

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The great value of this little volume is not alone in the subject matter. It furnishes teachers with the means of going very slowly and surely in the direction of making the year's work in geometry keep alive the students' knowledge of arithmetic and algebra and applying this knowledge in new situations. This sort of mathematical training, which enables students to use all their mathematical knowledge in any field of endeavor, is what is needed at the present time. When a teacher has used this book in connection with a standard textbook, it is possible that he may be willing to continue in the good work, and make real connections with physics, the machine and pattern shops, and so on.

H. E. C.

Manual for Classroom Drill Cards in Algebra, by John De Q. Briggs, Headmaster, St. Paul Academy, St. Paul, Minn. Edited by George W. Myers. 11×18 cm. Pages 42. 1921. Scott, Foresman & Co., Chicago.

The set of drill cards consists of 130 sets of ten cards each. The manual gives directions for use of cards and the answers to the exercises.

H. E. C.

Junior High School Mathematics, by John C. Stone, Head of the Department of Mathematics, State Normal School, Montclair, N. J. Book 1. 13×19 cm. Pages x+214. Book II. Pages vii+215. Book III. Pages viii+240. 1921. Benj. H. Sanborn & Co., New York.

The textbooks of this author are so well-known and have had so much influence in improving the teaching of mathematics that it needs be said only that in this series of books he has shown the same clear and immediate understanding of the kind of material and methods of presentation which are of the greatest value in the work of the junior high school Mathematics in this series is used to answer some necessary social question.

Book I applies arithmetic to many topics of personal, home, and community life, and to larger topics of general public interest. Constructive geometry and mensuration are also included. Book II completes the usual topics of arithmetic, introduces the simple equation, similar triangles, trigonometric ratios, the graph, measurements, and constructions. Book III is a course in general mathematics not only for the last year of the junior high school, but also for the first year of the four-year high school course. It gives a simple but adequate treatment of the essential parts of algebra and the practical parts of intuitive geometry. The closing chapter is a discussion of methods of interpreting statistics and of the three ways of measuring the central tendency of scattered data. Teachers of junior high school mathematics should examine this series.

H. E. C.

Methods of Teaching Vocational Agriculture in Secondary Schools, by Samuel H. Dadisman, Universty of California. 142 pages. 12½×19½ cm. Cloth. 1921. The Gooram Press, Boston, Mass.

This unique and splendid text is the outgrowth of the author's experience in the supervision of vocational agriculture. The information then is ripe. It has been written to better aid teachers in vocational agriculture. It is not based on theory alone but on real and practical points. There is some history of vocational education given. It bears down hard on the fertility of the soil and the reasons for understanding thoroughly what elements are contained in the soil in order to raise the best possible crops. The project method of teaching is splendidly illustrated. It is printed on uncalendered paper, thus avoiding the glare of reflection in reading. There are fifteen chapters and a splendid index. It is well worth while reading.

C. H. S.